STUDIES ON NEMATODES ASSOCIATED WITH PADDY

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By

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INTRODUCTION

In the recent years Phytonematology has received considerable attention in India. According to some estimates, the damage done to our crops by plant-parasitic nematodes may be as high as 50-90%. In addition to lack of irrigation facilities, proper fertilizers, adequate rains, good seed material etc., the nematodes are one of the important pests causing severe damage to our crops. Besides doing direct damage to our agricultural and horticultural crops, some of its species transmit pathogenic soil-borne viruses to their host plants. Mechanical injury caused by nematodes while feeding on plant-roots is liable to secondary bacterial and fungal infections which further aggravates the situation.

The paddy (Oryza sativa L.) is one of the important crops of India and thus needs greater attention. It is attacked by a variety of insect pests, fungi as well as nematodes. The species of the genera Hirschmanniella and Aphelenchoides are known to attack paddy plantations in different parts of the World. The first one is the principal paresite of paddy because of its universal occurrence. Van Breda de Haan (1902) for the first time demonstrated that Hirschmanniella oryzae was in some way associated with the 'mentek', one of the most destructive rice disease of Java. Van der vecht and Bergman (1952) carried

out further investigations to determine the pathogenecity of this nematode.

The first record of the plant-parasitic nematodes attacking paddy in India was made by Butler (1913) when he found Ditylenchus angustus associated with 'Ufra' disease of rice in Bengal. The 'White-tip' disease of rice caused by Aphelenchoides besseyi and A. oryzae, was reported from India by Dastur (1936). Later on Yoshii (1946) from Japan, Cralley (1949) from U.S.A. and Timm (1955) from East Pakistan also recorded white-tip disease of rice. Luc and Bredan Brizuela (1961) found Heterodera oryzae associated with severe damage to paddy in Africa. The following species of nematodes are known to attack paddy in different parts of World (cf. J.B. Goodey, et al., 1965): Aphelenchoides besseyi; Aphelenchoides sp.; Criconemoides rusticum; Ditylenchus angustus; Helicotylenchus multicinctus; Helicotylenchus sp.; Heterodera oryzae; Hirschmanniella oryzae; Hirschmanniella spinicaudata; Hoplolaimus galeatus; Meloidogyne arenaria var. thamesi; Meloidogyne incognita var. acrita; Meloidogyne javonica; Meloidogyne sp.; Pratylenchus pratensis; Pratylenchus sp.; Tylenchorhynchus martini and Tylenchorhynchus sp.

For the sake of convenience, the thesis has been divided into 3 parts. Part I provides a detailed account on the morphology of Hirschmanniella oryzae, a widely distributed species in Uttar Pradesh, together with its intra-specific variations. Part II deals with the taxonomy of nematodes of paddy. In all,

111 species of nematodes are reported, including 20 new ones which are described in detail. In addition, some of the already known species have also been redescribed if it was thought necessary. Except for Miconchus indicus n. sp. which was collected from Chittaurgarh, Rajasthan all the other species were collected in Uttar Pradesh. The species belong under 64 genera, 36 families and 14 superfamilies of 3 orders viz., Tylenchida, Dorylaimida and Mononchida. The 20 new species reported in the thesis belong under the following genera: One Ditylenchus Filipjev, 1936; 4 Helicotylenchus Steiner, 1945; one Hoplolaimus Daday, 1905; one Pratylenchus Filipjev, 1936; 2 Hirschmanniella Luc & Goodey, 1963; one Pratylenchus Micoletzky, 1922; one Nothotylenchus Thorne, 1941; one Sakia S.H. Khan, 1964; 2 Seinura Fuchs, 1931; one Discolaimium Thorne, 1939; one Paralongidorus Siddiqi, et al., 1964; one Leptonchus Cobb, 1920; one Oionchus Cobb, 1913; and one Miconchus Andrassy, 1959. The Part III of the thesis gives a complete list of nematodes obtained from soil around roots of paddy from different parts of Uttar Pradesh.

MATERIALS AND METHODS

Soil sampling:

Soil samples were collected from paddy nurseries, fields with standing crop and also from harvested fields. The soil was taken from a depth of 0-15 cm. along with the roots. Twentyfive subsamples were taken to form a bulk sample, from a field having an area of about one hectare. These samples were then brought to the laboratory in polythene bags for isolation of nematodes. If not immediately processed, the samples were kept in refrigerator at 5-7°C.

Processing of samples:

i) Soil: About 500 ml. of soil was taken in a bucket filled 1/3rd of its volume with water and mixed thoroughly so as to obtain a homogenous suspension. After waiting for about 10-20 seconds during which the heavy soil particles settle down at the bottom of the bucket, the suspension was then passed through a coarse sieve. The latter removes the stones, leaves, undesirable organic matters etc., from the muddy suspension. This process was repeated twice. The final suspension was passed through a set of 2 sieves of 300 mesh number (pore size 53 μ). The fine soil particles escape through the sieves while the large particles along with the nematodes etc., were retained.

The entire 'catch' from both the sieves was collected in beakers for the further processing.

ii) Roots: Roots of paddy were thoroughly washed with water, chopped into small pieces of about 1 cm. and masscerated in a 'Braun' blender at top speed for 10-15 seconds. The homogenate so obtained was passed through a set of sieves of 50 and 300 mesh numbers. While root fibres were left on 50 mesh sieve, the fine particles along with the nematodes were retained on 300 mesh sieve. The 'catch' from 300 mesh sieve was collected in another beaker for further investigations.

Isolation technique:

The aliquots collected by the above mentioned techniques were poured on nylon filters placed on small sized coarse sieves. These were kept in petri-dishes filled with water just touching the bottom of the sieves. The nematodes migrate through the filters into the clear water of the petri-dish in 24-48 hours. The residue on filters was examined under a stereoscopic binocular microscope for sluggish nematodes, such as criconematid nematodes.

Killing and fixing of the nematodes:

The suspensions containing nematodes were transferred to 50 ml. tubes. The nematodes were allowed to settle down at the bottom of test tubes for 2-3 hours and most of the supernatant

fluid was discarded. The nematodes were killed by hot 8% formaldehyde solution (double strength) and were left in this solution for at least one day. The nematodes were stored in the same solution.

Mounting and sealing:

Temporary mounts whenever needed were prepared either in water or in 4% formaldehyde solution. For permanent mounts, the nematodes were transferred to a mixture of glycerine and 30% alcohol (glycerine 5 parts:alcohol 95 parts) and were kept in a desiccator at room temperature for about 2-3 weeks. The dehydrated nematodes were mounted in anhydrous glycerine either on glass slides or on metallic slides.

Temporary mounts were sealed with a mixture of 50% wax and 50% vaseline, while the permanent mounts with 'Cutex' natural color nail-polish or 'Glyceel'.

Measurements and drawings:

De Manian formula for denoting the dimensions of the nematodes has been used. An ocular micrometer was used for taking measurements. The illustrations were made with the help of camera lucida. The original drawings have been made on white art card using India ink.

Type material:

The type material has been labelled and deposited with the Zoology Museum of the Department of Zoology, Aligarh Muslim University, Aligarh, U.P.

Part I.

Morphological Studies on

HIRSCHMANNIELLA ORYZAE (Soltwedel, 1889) Luc & Goodey, 1963

The genus Hirschmanniella Luc and Goodey, 1963 is cosmopolitan in its distribution and an established parasite of paddy, banana etc. Sanwal (1957) gave a good account of the morphology of one of its widely known species, H. gracilis (de Man, 1880) Luc and Goodey, 1963. Cher (1968) gave an excellent revision of the genus which to-date includes 16 species. The species, H. oryzae (Soltwedel, 1889) Luc and Goodey, 1963 is of common occurrence around paddy in this country and also in Japan, Formosa, Malaysia, Nigeria, Venezuela, San Salvador, Indonesia, Ghana etc. Taking into account the world wide distribution of the genus and its economic importance, it was proposed to undertake detailed morphological study of H. oryzae which is the most common species of the genus in India. The morphological studies are important in the sense that they provide pertinent information on a particular species and its intra-specific variations. This certainly has a direct bearing on the taxonomy of the genus concerned and also on the related groups. The utility of a structure as taxonomic character can only be judged by adequate study of the morphology based on large number of specimens obtained from different populations.

The present study is based on the specimens obtained from the natural populations of the nematode. The observations were made on fixed as well as on live specimens. In all, about eight hundred specimens of H. oryzae were studied.

STAINING TECHNIQUES

The specimens for the morphological study were stained with different techniques for obtaining various structural details. The gross morphology was studied on the specimens stained with the saturated solution of Picric acid. Intra-vital staining was done with different stains but the best results were obtained with Methylene blue. In particular, it was helpful in the study of excretory and digestive systems of the nematode. First, the specimens were kept for two hours in Methylene blue then fixed in Picro-carmine. Methyl red was also tried as intra-vital stain but it gave poor results.

Cuticle and associated structures:

The cuticle and its modifications were best studied with a slightly modified Cajal's method for the study of the tissues. The living nematodes were transferred in a vial containing a mixture of fresh 2% Silver nitrate solution and absolute alcohol (Ethyl alcohol) in the ratio of 10:1 as recommended by Sanwal (l.c.). The solution was then agitated by a fine pipette so as to straighten the dying nematodes. For better results the vial was wrapped in black paper before transferring the Silver nitrate solution. The Silver nitrate was also made slightly acidic by adding a few drops of Nitric

acid. The vial containing the nematodes was firmly corked and kept in a thermostat at 35°C for 48 hours. Afterwards, the specimens were washed two to three times with distilled water and transferred to a mixture of Hydroquinone and Formalin in the following proportions: 2 gms Hydroquinone, 10 cc Formalin in 100 cc distilled water.

The worms when transferred to this medium assume a dark brown appearance. Afterwards, they were transferred to a mixture of glycerine-alcohol (5 parts glycerine : 95 parts 30% alcohol) and then processed as usual. This method gives excellent details of cuticular structures including transverse striae, lateral fields, amphids, phasmids, oral aperture, anal opening, excretory pore etc. It also stains the reproductive organs especially the nuclei of the oocytes, spermatocytes and that of the esophageal glands. An attempt was made to study the nervous system by staining it with Silver impregnation technique but poor results were obtained, more so, because the entire nervous system leaving aside the nerve ring and associated cells is very delicate and difficult to study in such a small nematode. For the study of sphincter muscles encircling the excretory bulb of the terminal excretory duct and outlet of the terminal duct some specimens were kept in a mixture of Picric acid and A.F.A. for about two weeks.

For detailed study of the muscles the following method was found good:- First of all, living nematodes were stained

with Methylene blue and then were fixed in Picro-carmine. Later on, they were transferred to Haematoxylene and finally to a mixture of Aniline blue, Orange red, and Acetic acid (in equal proportions). After keeping the nematodes in this mixture for two weeks they were treated with Lactophenol. Specimens were then mounted in anhydrous glycerine by usual technique.

Chang's nerve stain (Theonin 0.3 gm., Formaldehyde 4% 10 cc and distilled water 90 cc) was found to be a good medium for the study of nervous system.

TABLE I

DIMENSIONS OF HIRSCHMANNIELLA ORYZAE

ALIGARH POPULATION (10)

FEMALES(56)

Measurements	Jamalpur North (73)	Jamalpur East (58)	Bhambhola (55)	University Agricultu-ire Farm A (56)	University Agricultu-ire Farm B (48)	Qasimpur North (45)	Qasimpur South (57)	Zorub Bagh (56)	Central Dairy Farm Road A (56)	Central Dairy Farm Road B (56)
LENGTH = 1.34 (1.00-1.59)mm. (in mm.)	1.01-1.49	1.10-1.45	1.12-1.40	1.00-1.54	1.01-1.56	1.00-1.59	1.00-1.53	1.15-1.54	1.06-1.54	1.00-1.57
a = 52 (32-60)	46-53	43-60	39-56	39-58	32-60	40-60	37-56	40-59	41-58	43-57
b = 11.2 (7.6-13.1)	8.7-11.5	8.1-13.7	7.6-11.9	8.0-11.1	8.0-11.3	7.8-12.6	7.8-13.1	8.7-11.2	8.5-11.5	8.6-13.1
b'= 5.0 (3.2-6.7)	4.1-6.4	5.1-6.7	4.1-5.7	4.1-5.6	3.3-5.4	3.4-5.9	4.1-6.6	3.7-6.3	3.9-6.1	4.3-6.1
c = 19 (13-27)	15-22	14-20	17-23	16-26	15-27	16-23	15-22	19-27	15-25	16-23
V = 24 22 17-43 17-41 53 (46-67)	48-57	46-56	48-67	46-61	48-58	48-53	48-51	46-57	46-63	48-53
G_1= 24 (17-43)	19-22	17-23	19-43	18-23	19-38	17-29	19-27	18-32	18-29	19-24
G_2= 22 (17-41)	18-20	17-22	20-41	16-21	15-29	18-23	16-33	17-26	18-23	16-21
Spear length = 17 μ (15-19 μ)	16-18 μ	15-18 μ	16-19 μ	15-17 μ	15-18 μ	15-19 μ	16-18 μ	16-19 μ	17-18 μ	15-19 μ
Metacorpus = 68 μ (56-86 μ)	66-80 μ	59-81 μ	59-83 μ	58-73 μ	59-85 μ	60-82 μ	59-81 μ	58-82 μ	59-86 μ	59-83 μ
Excretory pore	80-120 μ	83-110 μ	83-95 μ	87-113 μ	82-115 μ	85-117 μ	91-119 μ	93-120 μ	80-120 μ	83-111 μ
Dorsal esophageal gland overlap	212-350 μ	210-320 μ	215-291 μ	214-330 μ	230-310 μ	250-319 μ	220-293 μ	215-281 μ	214-273 μ	220-333 μ
Vulval slit = 9 μ (8-10 μ)	9-10 μ	8-9 μ	8-10 μ	9-10 μ	9-10 μ	9-10 μ	8-10 μ	9-10 μ	8-10 μ	8-10 μ
Vagina length = 10 μ (8-12 μ)	10-12 μ	8-12 μ	8-11 μ	9-12 μ	8-12 μ	9-10 μ	10-12 μ	9-12 μ	8-11 μ	8-10 μ
Tail length = 85 μ (70-120 μ)	73-80 μ	73-80 μ	71-82 μ	73-91 μ	73-80 μ	73-89 μ	71-89 μ	73-95 μ	73-85 μ	73-120 μ
Tail striae = 50 (50-80)	50	50	50	50	50	50	50	50	50	50-80.
Rectum = 16 μ (15-18 μ)	16-17 μ	16-18 μ	15-17 μ	15-18 μ	15-18 μ	16-17 μ	16-18 μ	16-18 μ	16-18 μ	15-18 μ.
Anal body-width = 17 μ (15-24 μ)	17-20 μ	17-19 μ	16-22 μ	17-24 μ	16-22 μ	17-22 μ	17-23 μ	15-19 μ	17-18 μ.	15-19 μ.
Phasmids.	13-82 μ	14-23 μ	16-22 μ	21-24 μ	16-23 μ	17-29 μ	23-26 μ	16-39 μ.	16-33 μ.	22-52 μ.

G_1 = Anterior gonad ... G_2 = Posterior gonad

TABLE II

DIMENSIONS OF HIRSCHMANNIELLA ORYZAE

ALIGARH POPULATIONS (10)

MALES(210)

Measurements	Jamalpur North (27)	Jamalpur East (22)	Bhambhola (22)	University Agricultu-ire Farm A (21)	University Agricultu-ire Farm B (18)	Qasimpur North (20)	Qasimpur South (20)	Zorub Bagh (21)	Central Dairy Farm Road A (19)	Central Dairy Farm Road B (20)
LENGTH = 1.45 (1.04-1.94) mm. (in mm.)	1.10-1.56	1.04-1.46	1.24-1.76	1.16-1.80	1.23-1.46	1.37-1.56	1.20-1.70	1.11-1.80	1.32-1.92	1.46-1.94
a = 54 (37-62)	37-48	37-53	39-64	39-62	41-56	53-59	52-56	42-58	43-60	43-62
b = 10.5 (7.0-12.8)	7.6-11.3	7.4-11.2	7.6-11.5	7.6-11.6	7.6-12.0	8.2-12.6	8.1-12.0	7.3-11.9	7.6-12.2	8.7-12.8
b'= 4.9 (3.6-6.1)	3.9-5.4	4.1-5.3	3.9-4.9	3.8-5.3	3.9-5.6	4.1-6.0	3.9-5.9	4.3-5.0	4.1-5.3	4.3-6.1
c = 18 (16-22)	17-21	16-22	15-19	15-17	17-21	16-18	15-17	16-21	15-21	17-22
T = 33 (24-42)	26-36	28-39	27-41	28-33	29-38	27-42	29-38	30-42	24-36	29-39
Spicules = 26 μ (22-29 μ)	23-29 μ	22-29 μ	22-28 μ	24-29 μ	24-29 μ	22-29 μ	22-27 μ	22-26 μ	22-29 μ	22-29 μ
Gubernaculum = 8 μ (7-10 μ)	7-9 μ	7-10 μ	7-9 μ	7-9 μ	7-9 μ	7-9 μ	7-9 μ	7-9 μ	7-9 μ	7-10 μ
Caudal alae = 73 μ (58-80 μ)	58-73 μ	58-80 μ	58-80 μ	58-75 μ	58-79 μ	58-76 μ	58-80 μ	58-73 μ	58-80 μ	58-80 μ
Rectum = 22 μ (19-24 μ)	19-22 μ	19-23 μ	19-24 μ	19-24 μ	19-24 μ	19-24 μ	19-24 μ	19-24 μ	19-24 μ	19-24 μ
Phasmids	16-22 μ	17-25 μ	18-32 μ	16-35 μ	16-42 μ	16-43 μ	10-46 μ	15-43 μ	15-46 μ	15-48 μ

GENERAL BODY SHAPE

(Plates I & II)

The worms are irregularly coiled, whitish to bluish-green in colour while alive. In water, the worms start swarming in a few hours time. Their characteristic movement helps in quick detection under the Stereoscopic binocular microscope. The nematodes upon fixation assume ventrally arcuate posture, slightly narrowing anteriorly above the level of esophago-intestinal junction and sharply behind the anus. The width of body in the middle third is nearly uniform, except at vulva where it is maximum.

Head:

The head is slightly marked off from the body by a faint constriction, slightly hemispheroid in shape, 3 u high and 8-9 u wide. It is supported by a well developed hexa-radiate framework, formed by the fusion of six strong radially placed cuticularized ridges. The inner edges of these ridges at their extremities converge to form a tube-like structure which serves as a guide for the spear. The outer edges of these ridges form a disc-like basal plate (Fig. V, D).

Lip region is rounded, flat at apex. En face view shows the usual six lips: two lateral, two dorso-lateral and

two ventro-lateral. Each lip bears a minute papilla at its inner margin. In addition, there are four pairs of outer cephalic papillae, one pair on each dorso-lateral and ventro-lateral lips, the lateral lips having only one papilla on their outer margins but they also possess the amphidial apertures (Fig. VI-A).

Tail:

The tail is more or less cylindrical (Fig. IV, A-N) with blunt tip, usually with a distinct mucro. The dorsal surface of the tail is usually straight while the ventral side curves inward. Tail length varies from 70-120 u (averaging 85 u) or 4-6 anal body-widths (averaging 5 anal body-widths), possesses pore-like phasmids on the lateral sides in the posterior half of its length. The usual number of tail striae is 50, but in few specimens it may have as many as 80 striae.

CUTICLE AND ITS MODIFICATIONS

(Plate: III)

The cuticle is almost uniformly thick throughout the body except at vulva, anus and at tail tip. It is about 1 u thick on the general body surface, about 2 u at vulva and anus while 2-3 u at tail tip. Transverse and longitudinal markings on the cuticle can easily be observed at low magnification in the specimen treated with Silver nitrate solution. However, detailed study of the cuticular sculpture was done always under higher magnifications or under immersion oil objective.

Transverse striations:

The head bears usually 6 fine, but distinct transverse striae placed at less than 1 u apart. The number of head striae is constant, with the exception that rarely 5 striae may also be present. In the region of spear, the striae are of the same width as those on the head. Posterior to spear the striae become more and more distinct with the increase in the inter-strial width, becoming about 2 u near the middle of the body. Posterior to middle this distance gradually decreases to about 1 u near the tip of the tail. In few specimens, the inter-strial width remains uniform until the

tail tip. In one specimen the inter-strial width was found to be of two different alternating thickness 1 & 2 μ on the body without any uniformity.

Mucro:

The cuticle at tail tip projects into a sharply pointed, peg-like 'mucro'. The length of the mucro varies from 1-3 u. In some specimens, the mucro is inconspicuously developed or even absent, this might have occurred due to some mechanical injury to the nematode.

Lateral fields:

The lateral sides of the body are marked with four longitudinal incisures (lateral lines) overlying the lateral hypodermal chords. These markings are more prominent in the middle part of the body. They originate just behind the level of spear base as a single depression in the cuticle, run as single line until the middle of procorpus and then are joined by the second incisure, the third one originates slightly posterior to the second incisure. These three incisures follow a parallel course upto the median bulb. Afterwards, the middle one (first incisure) splits up into two at the level of nerve ring,and the number of incisures become four. In a cross section (Fig. VI, D) at the level of metacorpus, the lateral sides show two strong ridges

and three grooves formed by the three incisures. In the region of nerve ring and posteriorly a cross section (Fig. III, G-K) shows three strong ridges with four depressions formed by the four incisures. The width of the lateral fields in the region of metacorpus is 4-5 u, at nerve ring 5-6 u and near the middle of the body about 8 u (6-10 u) or 1/3rd the corresponding body-width. The width of lateral fields is maximum at vulva. In the post-vulval region the lateral fields begin to narrow, in tail region the incisures run close to each other and start converging. In males, the width of the lateral fields is almost uniform from the esophago-intestinal junction to the beginning of the caudal alae, about 16-20 u above the cloaca.

The termination of lateral fields is quite different in the two sexes. In females (Fig. III, F), the incisures terminate 5-20 u above the tip of tail. The width of lateral fields decreases due to convergence of incisures in the post-vulval region, but the narrowing becomes conspicuous only in the anal region. Usually, the inner two (median incisures) disappear at about 10-20 u above the tip of the tail followed by the ventral and dorsal ones which terminate at about 5-15 u above the tip of tail. In males (Fig. III, H), posterior to the origin of caudal alae, the ventral and the inner two incisures run a short distance on the two wings of the alae where they expand and gradually disappear, usually above or occasionally slightly below the cloacal aperture.

The ventral incisure disappears first, followed by the inners. The dorsal incisures runs along the dorsal margin of the caudal alae and diminishes at 5-15 u above the tip of the tail.

Areolation (Fig. III, D-F):

The lateral fields are usually incompletely areolated. The areolation is caused by intrusion of transverse striae into the lateral fields. In the anterior half of the body, the areolation usually does not extend through the entire width of the lateral fields (incomplete areolation), but sometimes it may be almost complete. However, irregularities are very common in the occurrence of complete and incomplete areolation. It has been observed that in the pre-vulval region, the areolation is mostly confined to the outer bands of the lateral fields, the middle band is rarely crossed. However, in vulval and post-vulval regions, the outer as well as median bands of incisures are all interrupted by the transverse striae which may make complete rings around the body of the worm. In a number of specimens the areolation was complete throughout the length of the lateral fields. The areolation in the pre-vulval region is generally incomplete, but in post-vulval region it is mostly complete.

Anastomosis (Fig. III, C and G):

The phenomenon of anastomosis is rarely observed in nematodes, except in Criconematids. However, here it was observed in several specimens. Striations from head to tail are adversely effected in some of the specimens studied. The anastomosis may cause difficulties in the study of lateral fields because both the transverse and longitudinal striae show anamolies in their normal pattern. In specimens showing anastomosis, the lateral fields follow a random course, they do not run parellel to each other and show interruption at several places with the result that they do not look as incisures but as uneven lines made up of several small units. The overlapping of transverse striae was seen on any region of the body and they also do not form complete rings.

Caudal alae (Fig. III, I-K):

The males of the species have a pair of wing-like structure known as caudal alae which are sometimes referred to as 'bursa'. The term bursa is incorrect as this structure is neither supported by rays nor ribs as in the Strongylid nematodes. The caudal alae is formed due to the lateral extentions of the body cuticle. They originate about 15-20 μ above the cloacal aperture on the lateral sides of the body and terminate before the tip of the tail and thus do not envelop the tail completely. The alae in the anterior half

of their length are distinctly convex, but gradually narrowing on the rest. The outer edges of the alae are crenate due to the continuation of the transverse striae of the body. The alae normally neither originate at the same level on the body nor do they terminate.

The relation of caudal alae with the phasmids is variable. In most of the specimens, it was found that while one ala reaches beyond phasmids, the other one stops slightly short; in few specimens, both the alae reach beyond the level of phasmids. However, it was never found to end before the phasmidial level.

Amphids (Fig. VI, A):

The amphids are situated on the lateral sides of the body in the head region. The amphidial slits 2-3 u wide are crescentric in shape, situated on the lateral lips. The amphidial ducts have ellipsoidal pouch-like structure which are known as sensillar pouches, the latter being innervated by minute fibres from the cephalic sensory nerves (Fig. VIII, A).

Cephalids (Fig. III, A):

The cephalids are present in the stomal region. The first or the anterior cephalid is situated 2-4 striae behind the basal plate. The second cephalid can be seen at about

the level of spear knobs. The cephalids form complete rings around the body of the worm.

Hemizonid:

The hemizonid appears laterally as a cup-shaped structure, highly refractive in nature. It is situated in the vicinity of the excretory pore, usually 2-8 body strine above the former, 2-3 body strine long. The hemizonid is supplied with prominent nerve fibres arising from the nerve ring (Fig. VIII, A).

Phasmids (Fig. III, F-K):

The phasmids are located on the posterior half of the tail on the lateral sides as refractive pore-like structures. The position of the phasmids is variable and in the same specimens they are not situated at one level. The phasmids are situated in between the median incisures. Sometimes abnormally they are situated below the termination of the incisures but in the centre of the lateral fields.

HYPODERMIS

(Fig. V, F)

The hypodermis is a rather thin, syncytial layer which is thickened at four points to form the longitudinal chords. These thickenings are dorsal, ventral and lateral in position. Towards the anterior and posterior ends of the body these chords are rather poorly defined. Anteriorly they originate just behind the spear base, becoming prominent in the region of median bulb and continue as such up to the level of anus where these chords become less prominent and finally disappear at the hinder end of the tail. In cross sections of the body (Fig. VI, D-L) at different levels, these chords can be clearly seen bulging out in the body cavity (pseudocoel) in the dorsal, ventral and lateral positions of the body. However, the dorsal and ventral chords appear to be slightly different in shape and comparatively more prominent than the laterals. The lateral hypodermal chords posterior to level of excretory pore enclose the lateral excretory canals. These four hypodermal chords divide the visceral cavity though incompletely into four quadrants in which sets of somatic muscles are arranged.

MUSCULATURE

(Plate: VII, A-G)

The muscles in the body of the nematodes were studied under two headings: 'Somatic or unspecialised musculature' and 'Specialised musculature'.

Somatic or unspecialised musculature (Figs. VII, A-C):

Each quadrant of the hypodermis is provided with 4 cells which are flat at the point of their attachment with the hypodermis. Thus the nematodes are typical meromyarian with platymyarian type of somatic musculature. The number of muscle cell was found to be always constant, i.e., 4 cells per quadrant from the region of spear to anus, but normally they are more prominent towards the middle of the body and less towards extremities depending upon the width of the body. The 'thorneian cells' of Sher (1968) could not be detected in this species.

Specialised musculature:

In addition to the somatic muscles there are 'specialised muscles' associated with the various organs of the body to help them in their activities. The various body parts such as spear, esophagus, intestine, spicules, gubernaculum, etc., each

having muscles attached to them. In addition, all the openings to the exterior are guarded by specialized type of muscles known as sphincters.

(i) Spear muscles (Fig. V, A-D and VI, B and C):

There are four primary sets of muscle bands associated with the spear, but each set is ultimately subdivided. Thus there appear to be 8 muscle bands. They are attached to the base of spear knobs at one end and to the basal plate of the lip region at the other. These muscles serve for the forward and backward movement of the spear. When the nematodes are relaxed by gentle heat these muscles keep the spear in its natural position.

(ii) Somato-esophageal muscles:

Associated with esophagus. Not very prominent.

(iii) Somato-intestinal muscles:

Associated with intestine. Not very prominent.

(iv) Vulval muscles:

There are several sets of muscles associated with the vulva and help in the dilation and contraction of the vulval opening. These are primarily of two types:

(a) Dilator vulvae (Fig. VII, D-G: 2):

They consist of eight muscle bands, 4 anterior to vulva and 4 posterior. These sets are arranged in 4 pairs - 2 anterior and 2 posterior to vulva. They originate from vulva and run ventro-laterally. These vulval muscles in association with the sphinctor muscles control the dilation of vulva.

(b) Constrictor vulvae (Fig. VII, D-G: 1):

The constrictor vulvae consist of four muscle bands. They are attached to the base of the vagina at one end and to the latero-ventral body wall at the other end.

(v) Anal muscles (Fig. VII, H: 3):

A single muscle band in the anal region of female extends from the lower margin of the anus to the subdorsal wall of the body. This muscle band is also present in males, but is inconspicuous.

(vi) Spicular muscles (Fig. VII, I):

There are several sets of muscle bands associated with the spicules of the males to bring about its movements. These muscles are retractor spiculi and protractor spiculi.

Retractor spiculi:

(a) Latero-ventral retractor spiculi (Fig. VII, I: 4):

A pair of muscle bands on each side extends from the head of spicules to the body wall in between the latero-ventral somatic muscles.

(b) Latero-dorsal retractor spiculi (Fig. VII, I: 6):

A pair of muscle bands on each side extends from the head of the spicules to the body wall in between the latero-dorsal somatic muscles.

Protractor spiculi:

(a) Right and left external protractor spiculi (Fig. VII, I: 6&7):

They extend from the lower margin of the head of spicules, and are inserted in the anterior region on the latero-ventral wall of the tail region.

(b) Internal protractor spiculi (Fig. VII, I: 8):

They are less prominent, extending from the lower part of the head of spicules to ventro-lateral wall of the body.

(c) Anterior protractor spiculi (Fig. VII, I: 9):

They extend from the posterior side of the head of spicules, and are inserted straight on the lateroventral wall.

(vii) Gubernacular muscles:

The muscles associated with the gubernaculum are of following three types:

Retractor gubernaculi (Fig. VII, I: 10 and 11):

A set of muscles extending from the distal part of the gubernaculum to the latero-dorsal wall of the body.

Protractor gubernaculi (Fig. VII, I: 12 and 13):

They are strongly developed as compared to other muscles associated with the gubernaculum. They extend from the proximal end of the gubernaculum to the subventral body wall and are known as right and left protractor gubernaculi depending upon their position in the body.

Seductor gubernaculi (Fig. VII, I: 14 and 15):

These muscles are clearly visible only in the ventro-dorsal view, laterally they are obscure. They extend from the proximal end of the gubernaculum to the latero-ventral body wall of the worm and are known as right and left seductor gubernaculi depending upon their position in the body.

(viii) Copulatory muscles (Fig. VII, I: 16):

The paired copulatory muscles described by Coomans (1963) in Hotylenchus goodey are not distinct in this worm.

However, a band of muscles in the pre-anal region, extending from latero-ventral position of the body wall to latero-dorsal body wall is distinct in some of the specimens in addition to post-anal muscle bands. These muscles may be copulatory in function.

DIGESTIVE SYSTEM

The digestive system of the worm is made up of the following parts:

i) Stoma
ii) Procorpus
iii) Metacorpus
iv) Basal glandular part of esophagus
v) Intestine
vi) Rectum
vii) Anus

Stoma:

The region between the oral aperture and the spear base is termed pharynx, oral cavity, buccal cavity or stoma. This part of the digestive system is connected to the oral aperture which is guarded by six lips and is supported by sclerotized ridges along the six radii which form the head framework. The oral aperture leads into a narrow cavity formed by the union of the inner extremities of the six ridges which provide a passage for the forward and backward movement of the spear. The spear measures 15-19 u (average 17 u) in length and is divisible into anterior conical part (metenchium) and posterior cylindrical part (telenchium); the latter is

provided with three well developed knobs at its base. The spear helps in feeding and its action can be compared with that of hypodermic needle. It punctures the root-cells by continuous forward and backward thrust. The secretions of the esophageal glands flow through the lumen of the spear into the root-cells and thus partly digest the plant tissues. The lumen is narrow but uniform throughout the length of the spear. The movement of spear is brought about by means of the four paired muscle bands discussed earlier.

Esophagus:

The esophagus of the worm is divisible into an anterior procorpus or precorpus, metacorpus or median bulb, the isthmus, and the glandular lobe overlapping the intestine. The procorpus or the proximal part of the esophagus is a slender tube narrowing at both the extremities. The lumen of the procorpus is uniform throughout its length. In the anterior part of the lumen of procorpus opens the duct from the dorsal esophageal gland at 2-3 u behind the base of the spear. The distal end of procorpus is connected to the median bulb through a narrowing. The median bulb is an ovate muscular organ which has well developed crescentic valvular apparatus. It is situated at 56-85 u from anterior end of body. In the specimens stained by modified Cajal's method (Sanwal, 1957), the median bulb shapes differently (Fig. V, F-J). In some specimens, it is pyriform, with a slight constriction in the middle. This shape

was evident in the lateral as well as in the dorso-ventral position. In all such specimens crescentic valvular plates remain in the anterior half while the ampullae of the two subventral glands occupy the available space (1/3rd of the total space) posteriorly. The ampullae of the subventral glands open just at the base of the crescentic valves. The function of the median bulb may be identical to the gizzard of the Oligochaeta, but the fact that they feed upon plants, clearly indicates that the worms do not eat anything which may need crushing for the purpose of digestion. It is, therefore, most likely that they help in sucking the plant juices by continuous contraction and expansion of the muscles and also regulate the forward and backward flow of the fluids through the esophageal lumen.

The isthmus connects the median bulb with the glandular lobe. It is a very narrow tube enveloped at its middle by the nerve ring.

The posterior glandular part of the esophagus which may also be called as end bulb, is narrow and refractive, forms a long ventral overlap over the intestine, measures 210-350 μ (average 295 u) in length. It is made up of three esophageal glands one dorsal, and two subventral in positions. All the three glands are enclosed in a bag of epithelial cells as evident from the cross sections of body in the esophageal region (Fig. VI, C). The glands have a prominent nucleus

situated at their hinder end or the lobular part of the esophageal glands. The dorsal gland is situated in anterior part of the lobe followed by the subventrals which occupy the middle and the posterior position. The duct from the dorsal esophageal gland passes through the isthmus and median bulb into the procorpus where it opens at the base of spear. Before opening into the lumen of the procorpus it forms a prominent ampulla. The two subventral esophageal glands also form distinct and prominent ampullae before opening in the median bulb at the base of valvular apparatus (Fig. V, G-J).

Intestine:

The esophago-intestinal junction is guarded by small cells which are refractive in nature. These cells were distinctly visible in those specimens which were specially stained for the study of muscles. The intestinal tube is narrow in the region where it is overlapped by the glandular part of the esophagus but posteriorly it occupies nearly all the available space. The intestine is supported by somato-intestinal muscles in the body cavity. It is pushed to dorsal side in mature specimens in order to accommodate the developing genital organs (Fig. I, A). In the posterior region it gradually narrows to join the rectum.

Rectum:

The rectum is a dorso-ventrally bent tube lined by the cuticle, measuring 16 μ (15-18 μ) in females and 22 u (19-24 μ) in males, slightly shorter than one anal body-width in females and slightly longer than one anal body-width or cloacal body-width in males. In males, the rectum opens along with the genital duct into cloaca. The cloaca is also lined by cuticle. The latter communicates outside through cloacal aperture.

Anus:

A circular openning (Fig.IV, N) in the posterior region of the body, midventral in position. Through this the alimentary canal communicates with the outside.

EXCRETORY SYSTEM

(Plate: VIII, H)

The excretory system comprises the longitudinal excretory ducts, terminal duct and excretory pore. The excretory pore lies on the midventral position of the body at or below the level of nerve ring. The excretory pore is guarded by a sphinctor. It leads into a terminal duct, which has a swelling in the anterior region giving it a beak-like appearance. The anterior and posterior extremities of this swelling are also provided with sphinctors. The sphinctors were seen in the specimens treated with A.F.A. The terminal duct runs posteriorly, after a distance of about 50-60 u it ends into an ampulla-like structure. The latter also receives the anterior and posterior longitudinal excretory ducts. The presence of a renette cell could not be confirmed with certainty. Sanwal (l.c.) also failed to locate it in Hirschmanniella gracilis. The lining of excretory ducts shows refractive spots which may be protoplasmic projections of the epithelial cells lining these ducts.

Sanwal (l.c.) was doubtful about the connection of ampulla with the excretory ducts. The present study which is based on a larger number of specimens clearly shows that there is definite connection between the two. The tubular

longitudinal excretory canals extend from the ampulla-like structure anteriorly and posteriorly (Fig. VIII, H). A transverse duct arising out of the ampulla is clearly visible. The anterior canal breaks up into two at about 25-30 μ from the excretory ampulla. These two branches cover up the anterior part of the body running laterally. In some specimens, they could be traced up to the base of spear. On the other hand the posterior duct is visible with distinction only in the pre-vulval region of the freshly stained specimens. The two canals are dilated, at several places throughout their lengths into ampulla-like structures. At these places, they are supposed to receive smaller excretory tubules from different parts of the body. The excretory ducts were also observed in living specimens where they appear smooth.

NERVOUS SYSTEM

(Fig. VIII, A-G)

The nervous system of the worm consists of a nerve ring, the ganglions and the nerves. In addition, there are scattered nerve cells which are also associated with this system and are perhaps sensory in function. The nerve ring which is the centre of nervous system is fibrous in nature. The ganglions (one ventral, one dorsal and two lateral) were visible only in some of the specimens. The nerves arising out of the nerve ring and the associated ganglions are delicate. Two nerves known as cephalic sensory nerves arise out of the dorsal and two ventral ganglion. Two more nerves one to each amphids, originate from the lateral ganglions, the branches of which also supply to the submedian lips. Branches from the nerve ring also supply the hemizonid, and cephalids. The nerve supply to other parts of the body such as excretory pore, digestive and reproductive systems, was observed in some of the specimens, but on the whole they are very faint.

Nerve cells:

A number of nerve cells were found scattered in the body, but they accumulate in the vicinity of nerve ring, vulva and cloaca. According to Sanwal (1957) the number of these cells in H. gracilis is definite but in the present material their number as well as distribution is variable.

REPRODUCTIVE SYSTEM

Sexes are separate, but there is no sexual dimorphism except for the differences in gonads and their associated structures. The males and females are found in ratio of 3:7 in the soil as well as in the roots of paddy.

Female reproductive organs (Fig. IX, A-L):

The female gonads are amphidelphic with outstretched ovaries. Each sexual branch consists of an ovary, an oviduct, a spermatheca and a uterus. The total space occupied by the gonads is 46% (40-75%) of the total body length. The anterior and posterior branches measure 285 μ (231-440 μ) and 268 u (234-416 μ) or 24% (17-43%) and 22% (17-41%) respectively of the total body length.

Each sexual branch consists of an ovary which is a long tubular structure lying ventral to the intestine. The oocytes are arranged in a single row, except in the region of the multiplication. In few specimens, the oocytes were found arranged uniformly in a single row. The nuclei of the oocytes are very prominent. The number of oocytes in each ovary varies from 37-42 (average 39). In some older females there were only 17-18 oocytes in one ovary.

The ovary leads into an oviduct which is a narrow muscular tube having almost a uniform width throughout its length. The oviducts of anterior and posterior sexual branches measure 87 μ (28-153 μ) and 91 μ (28-191 μ) respectively. The oviduct terminates into a round spermatheca which measures 14-22 μ X 7-10 μ. At the junction of oviduct and spermatheca, three pairs of unicellular structure are present. They may be glandular in nature. Their function could not be determined. The shape of spermatheca varies from a simple pouch to a more or less spherical structure (Fig. IX, D-F). In some females, it assumes somewhat oval or elongate shape. In the younger females the spermatheca is inconspicuous in the form of a swelling (Fig. IX, D) and assumes a definite shape upon the maturity of the worm. They are usually filled with oval to spherical sperms. The spermatheca lies at the oviduct-uterus junction. The proximal part of the uterus is muscular, while the distal is glandular. The distal part is also known as quadricolumella or 'shell-gland' part. The uterine or proximal part is more conspicuous in appearance than the quadricolumella region due to its having strong muscules which are used for the ejection of the eggs. The total length of the anterior uterus is 90 μ (58-197 μ) and of the posterior uterus is 80 μ (58-106 μ).

The uteri jointly open into the vagina. The vagina is 10 μ (8-12 μ), its walls are lined with cuticle. In lateral view, the vaginal walls show two distinct parts which have been

regarded as rods by Sanwal (l.c.). The anterior part is smaller than the posterior one. There are some cells conspicuously visible in lateral view which lie at the vagina-uteri junction. The vagina opens outside through a depressed transverse slit-like vulva 7 μ (6-8 μ) wide. In some of the specimens, the body wall is slightly raised (protruded) in the region of vulva. The position of the vulva is 63% (46-67) of the body length from the anterior end.

In one female, the anterior sexual branch was normal, but the posterior branch had a reflexed ovary (Fig. IX, I). In some females (Figs. IX, G and H) whose gonads were parasitized by a species of sporozoan , the sexual branches were extensively developed. Usually the anterior sexual branch ends well below the ventral esophageal gland lobe but in these specimens it reaches up to the middle of the subventral gland lobe of esophagus.

Male reproductive organs (Figs. X, A-J):

The male gonad consists of a testis, a vas deferens, an ejuculatory duct and the copulatory apparatus, and occupies 33% (30-43) of the total body length confining itself to the posterior half of the body. The testis is outstretched rarely reflexed (Figs. X, B and B1). The germ cells are arranged in a single file except in the zone of multiplication. The number of germs cells in the testis

varies from 49-69 (averaging 59). The testis leads to the vas deferens, which is thin and tubular at the anterior end, and thick and glandular towards the posterior end. The vas deferens (Fig. X, A_1) measures 230 μ (156-310 μ) and terminates into a narrow muscular ejaculatory duct which opens to the outside through the cloaca.

The associated copulatory structures are paired spicules, a gubernaculum and the caudal alae. Spicules are identical, each measures 25 μ (22-29 μ) medially and consists of a well developed head, a short neck, and a long concave tapering blade with blunt tips. There is a distinct membranous structure along the concave margin or the ventral side of the spicules. The gubernaculum is generally troughshaped, measures 8 u (7-10 μ) but it shows polymorphism (Figs. , C-J).

DISCUSSION

The observations on the morphology of Hirschmanniella oryzae show many intra-specific variations which are important for the taxonomic study of the genus Hirschmanniella and also have a bearing on the related groups. An evaluation of the diagnostic characters studied in H. oryzae is given below:-

The body shape upon fixation in the two sexes varies from an open "C" to almost straight. The body size ranges significantly. This variation may be as much as 0.45 mm from the mean. However, worms with considerable slender or stout bodies are of frequent occurrence thereby altering the value of 'a'.

The transverse striae may vary in nature and on any particular part of body may be fine or coarse, but extreme variations are rare. Normally the midbody has striae with greatest inter-strial width. They usually form complete rings on the head region before the appearance of the lateral incisures. The lateral fields interrupt the striae. Areolations are also present. The phenomenon of anastamosis of striae was seen in some specimens.

The number of incisures in the lateral fields was found to be constant, variations occur only in the manner of its termination. They may terminate 5-20 u from the tip of

tail, either above or below the level of phasmids. This is correlated with the fact that the position of phasmids is also variable. Therefore, the relation of phasmids with the termination of lateral incisures is no longer a dependable character for taxonomic purposes and should be used with caution after studying a large number of specimens.

The height and the width of the lip region ('head') are constant features and should be given importance. The shape of head is hemispheroid with or without a flat apex. In the specimens not fixed properly the actual shape of head may change to considerable extent. In order to determine the exact shape of head the specimens should be excellently preserved and neatly mounted. The number of head annules varies little, in the present specimens from 5 to 6, and is a good taxonomic character.

The average length of spear is 17 u ranging from 15 to 19 u. The deviations from the average length should be noted carefully. As recently pointed out by Taylor (1969), the spear, being a cuticularised structure, shows very little variations. Sometimes, it becomes rather difficult to see the tip of the spear and thus measure it accurately. This may result into error if proper care is not taken. In poorly fixed specimens, the head becomes a bit twisted and this results into faulty observations on the spear. Usually spear is slender in H. oryzae but abnormally it may be thicker

in some specimens. The spear knobs are always rounded and slightly sloping. There was hardly any variation in the shape of the spear knobs. Spear, therefore, should be given considerable importance in the separation of species of Hirschmanniella or any other Tylenchida.

The orifice of dorsal oesophageal gland is also quite constant. It varies 1 u anterior or posterior to its usual position which is negligible. Therefore, the distance of dorsal esophageal gland opening from spear base stands out as a dependable character.

The median bulb is always located posterior to middle of esophagus. The change in position, if considerable, may be important. This could not be found in the present species. The length and width of the median bulb has little value.

The relation of hemizonid with excretory pore is not very significant because the former is found 1-8 striae above the latter. Sometimes, the hemizonid appears double. Therefore, much importance to these two structures cannot be given. The excretory pore is always situated anterior to esophago-intestinal valve. This relation is very constant and should be given due consideration in the description of the nematode species.

Part II.

Taxonomic Studies on Nematodes of Paddy

ORDER TYLENCHIDA THORNE, 1949

SUBORDER TYLENCHINA (Thorne, 1949) Geraert, 1966

SUPERFAMILY TYLENCHOIDEA (Örley, 1880) Chitwood and Chitwood, 1937

FAMILY TYLENCHIDAE Örley, 1880

A number of nematodes belonging to family Tylenchidae were obtained from the paddy fields in Uttar Pradesh. They altogether represent 15 species of the following 6 known genera: Tylenchus Bastian, 1865; Ditylenchus Filipjev, 1936; Pseudhalenchus Tarjan, 1958; Psilenchus de Man, 1921; Basiria Siddiqi, 1959; Clavilenchus (Jairajpuri, 1966) Thorne and Malek, 1968.

SUBFAMILY TYLENCHINAE (Örley, 1880) Marcinowski, 1909

GENUS Tylenchus Bastian, 1865

The species of the genus Tylenchus are of frequent occurrence around paddy. The samples studied yielded the following 4 species.

Tylenchus striatus Das, 1960

Localities:

1) Barwe Sagar, district Jhansi

ii) Aurai, district Varenasi

iii) Barwa Samerpur, district Hamirpur

Tylenchus parvus Siddiqi, 1963

Localities:

i) Jamalpur, district Aligarh

ii) Niranjanpur, district Dehradun

iii) Balakpur, district Pilibhit

iv) Baroberia and Lodipur, district Shahjahanpur

Tylenchus arcuatus Siddiqi, 1963

Localities:

i) Qasimpur and Jamalpur, district Aligarh

ii) Sewla Kalan, district Dehradun

iii) Sakrar, district Jhansi

iv) Chauch, district Lakhimpur Kheri

v) Rosa, district Shahjahanpur

Tylenchus ritai Siddiqi, 1963

Localities:

i) Jamalpur, district Aligarh

ii) Collector Buck Gunj, district Bareilly

iii) Jogipura, district Bijnor

iv) Rishikesh, district Dehradun

v) Kasgunj, district Etah

vi) Malihabad, district Lucknow

vii) Partapur, Rijani, Uldhan and Setua, district Meerut

viii) Rohana, district Muzaffarnagar

ix) Lalaurikhera, district Pilibhit

x) Shahabad, district Hardoi

xi) Singhnapur, district Sitapur

xii) Haridwar, Luksar and Kaileshpur, district Saharanpur

xiii) Misripur, Rosa, Rasoolpur and Hathhauria, district Shahjahanpur

SUBFAMILY DITYLENCHINAE Golden, 1971

GENUS Ditylenchus Filipjev, 1936

The species of the genus Ditylenchus are rare in paddy fields. Four species of Ditylenchus have been recorded from different parts of Uttar Pradesh, of these one is new.

Ditylenchus nanus Siddiqi, 1963

Localities:

i) Jamalpur, district Aligarh

ii) Izzatnagar, district Bareilly

iii) Jogipura, district Bijnor

iv) Rijani, district Meerut

v) Haldwani, district Nainital

vi) Rosa, district Shahjahanpur

Ditylenchus triformis Hirschmann & Sasser, 1955

Locality:

Mussoorie, district Dehradun

Ditylenchus mirus Siddiqi, 1960

Localities:

i) Jamalpur, district Aligarh
ii) Sewla Kalan, district Dehradun
iii) Kasgunj, district Etah
iv) Ritha, district Meerut
v) Haldwani, district Nainital

Ditylenchus claviceudatus n. sp.

(Plate: XI, Fig. A-H)

Dimensions:

Female Paratypes (5): L= 0.80-0.89 mm.; a= 38-45; b= 6.5-6.9; c= 8-10; V= 73-77.

Female Holotype: L= 0.86 mm.; a= 43; b= 6.7; c= 10; V= 75.

Description:

Female: Body slightly curved ventrally posterior to vulva upon fixation. Transverse striae fine, less than 1 u apart on midbody. Lateral fields marked with 6 incisures,

occupying about 1/4th the corresponding body-width near middle.

Lip region set off. Spear 9-10 u, with small rounded basal knobs, the latter slightly divergent at base. Dorsal esophageal gland opening 3-5 u below the spear base. Esophagus typical of the genus. Basal bulb of esophagus slightly overlaps the intestine. Excretory pore in the anterior half of basal bulb. Hemizonid 1-3 striae anterior to excretory pore, about 2 striae long.

Vulva a depressed transverse slit. Ovary prodelphic outstretched. Post-uterine sac about 2 vulval body-widths long. Tail elongate, terminus clavate, 5-7 anal body-widths long.

Male: Not found.

Type locality: Aligarh University Agriculture Farm.

Type specimens: Holotype female on slide P-74 D. clavicaudatus n. sp./1; paratypes on slides P-74 D. clavicaudatus n.sp./2-3.

Differential diagnosis: Ditylenchus clavicaudatus n. sp. can be distinguished from all the other species of the genus Ditylenchus in having a clavate tail. However, it comes closest to D. caudatus Thorne and Malek, 1968 in having 6 incisures in lateral fields and long tail but differs in having flat, slightly set off lip region; post-uterine sac 2 vulval body-widths long;

and elongate, clevate tail (lip region rounded, not set off; post-uterine sac 1 vulval body-width long; and elongate tapering tail in D. caudatus).

GENUS PSEUDHALENCHUS Tarjan, 1958

Pseudhalenchus anchilisposomus Tarjan, 1958

Locality:

Lalauri Khera, district Pilibhit

SUBFAMILY PSILENCHINAE Paramonov, 1967

GENUS BASIRIA Siddiqi, 1959

Basiria graminophila Siddiqi, 1959

Locality:

Barwe Sagar, district Jhansi

GENUS PSILENCHUS de Man, 1921

Survey of paddy fields of the North-Western Uttar Pradesh yielded a number of specimens of this genus belonging to 3 species:

Psilenchus hilarulus de Man, 1921

Localities:

i) Jamalpur, district Aligarh

ii) Niranjanpur, district Dehradun

Psilenchus neoformis Jairajpuri, 1963

Localities:

i) Jamalpur, district Aligarh

ii) Sewla Kalan, district Dehradun

iii) Kailashpur, district Saharanpur

Psilenchus minor Siddiqi, 1963

Locality:

Sewla Kalan, district Dehradun

GENUS CLAVILENCHUS (Jairajpuri, 1966) Thorne & Malek, 1968

Clavilenchus tumidus (Colbran, 1960) Thorne & Malek, 1968

Locality:

Malihabad, district Lucknow

Clavilenchus ritteri (Baqri and Jairajpuri, 1969)

Baqri and Jairajpuri, 1969

Syn. Tylenchus (Clavilenchus) ritteri Baqri and Jairajpuri, 1969

Localities:

i) Kannuli, district Dehradun

ii) Peennakannauri, district Muzaffarnagar

FAMILY TYLENCHORHYNCHIDAE (Eliava, 1964) Golden, 1971

SUBFAMILY TYLENCHORHYNCHINAE Eliava, 1964

GENUS TYLENCHORHYNCHUS Cobb, 1913

The majority of samples analysed during the present investigations yielded a number of specimens of Tylenchorhynchus belonging to following 6 species:

Tylenchorhynchus mashhoodi Siddiqi and Basir, 1959

Localities:

i) Kannuli, Niranjanpur, Rishikesh, and Sewla Kalan, district Dehradun

ii) Luksar, Ranipokhar, Pathria, and Hasanpur, district Saharanpur

iii) Nagal, Rijani, and Ritha, district Meerut

iv) Kohana, Lakarsanda, Partapur, and Shamli, district Muzaffarnagar

v) Jamalpur, district Aligarh

vi) Nandawan, district Azamgarh

vii) Sisr, district Ballia

viii) Izzatnagar, district Bareilly

ix) Jogipura, district Bijnor

x) Kasgunj, district Etah

xi) Shahabad, district Hardoi

xii) Chauch, district Lakhimpur Kheri

xiii) Malihabad, district Lucknow

xiv) Haldwani, district Nainital

xv) Balakpur and Lalaurikhera, district Pilibhit

xvi) Hargaon, district Sitapur

xvii) Waheedpur, Rosa and Rasoolpur, district Shahjahanpur

xviii) Sagnakhera and Gyankhera, district Unnao

Tylenchorhynchus divittatus Siddiqi, 1961

Localities:

i) Barwe Sagar, district Jhansi

ii) Delhi Road fields, district Meerut

iii) Kailashpur, district Saharanpur

Tylenchorhynchus delhiensis Chawla, Bhamburkar, E. Khan and Prasad, 1968

Locality:

Rosa, district Shahjahanpur

Tylenchorhynchus brevidens Allen, 1955

Localities:

i) Laksar, district Saharanpur

ii) Ritha, district Meerut

Tylenchorhynchus capitatus Allen, 1955

Locality:

Haldwani, district Nainital

Tylenchorhynchus goffarti Sturhan, 1966

Locality:

Gyanpur, district Varanasi

FAMILY BELONOLAIMIDAE (Whitehead, 1959) Siddiqi, 1970

SUBFAMILY TELOTYLENCHINAE Siddiqi, 1960

GENUS TRICHOTYLENCHUS Whitehead, 1959

Trichotylenchus indicus (Siddiqi, 1960) Jairajpuri, 1971

Locality:

Saraikhas, district Shahjahanpur

Trichotylenchus aerolatus (Baqri and Jairajpuri, 1969)

Jairajpuri, 1971

Locality:

Barwe Sagar, district Jhansi

FAMILY HOPLOLAIMIDAE (Filipjev, 1934) Wieser, 1953

SUBFAMILY HOPLOLAIMINAE Filipjev, 1934

GENUS HOPLOLAIMUS Daday, 1905

Hoplolaimus indicus Sher, 1963

Localities:

i) Jamalpur, district Aligarh
ii) Ram Ganga, district Bareilly
iii) Mussoorie, district Dehradun
iv) Shahabad, district Hardoi
v) Sakrer, district Jhansi
vi) Chauch, district Lakhimpur Kheri
vii) Rijani, district Meerut
viii) Rohana, Peenna Kannauri, and Naugaon, district Muzaffarnagar
ix) Haldwani, district Nainital
x) Lalauri Khera, district Pilibhit
xi) Luksar, Kailashpur, and Salempur, district Saharanpur
xii) Abahin, Balliya, and Rosa, district Shahjahanpur
xiii) Sangnakhera, Mainikhera, and Naharya, district Unnao
xiv) Aurai, district Varanasi

Hoplolaimus columbus Sher, 1963

Some females of H. columbus have been collected from Balakpur, district Pilibhit. No males were recorded in this collection.

Hoplolaimus neoformis n. sp.

(Plate: XII, Figs. D-F)

Dimensions:

Female Paratypes (5): L= 1.46-1.82 mm.; a= 30-37; b= 10.8-11.2; b'= 8.0-8.3; c= 47-62; V= 53-56.

Female Holotype: L= 1.55 mm.; a= 27; b= 10.8; b'= 8.0; c= 47; V= 56.

Description:

Female: Body slightly arcuate ventrally upon fixation. Transverse striae about 2 u wide. Lateral fields marked by a single incisure.

Lip region conoid marked with 4 distinct transverse striae. Spear 45-48 μ long with anteriorly projecting knobs. Orifice of dorsal esophageal gland 4-6 μ below the spear base. Median esophageal bulb at 75% of the esophageal length* from anterior end of body. Esophago-intestinal junction 143-155 μ from anterior end of the body. Excretory pore in front of the

* Length of esophagus is measured from anterior end of the body up to esophago-intestinal valve.

esophago-intestinal valve. Hemizonid 2-3 body striae long, 8-12 striae posterior to excretory pore.

Vulva a depressed transverse slit, guarded by double epiptygma. Gonads amphidelphic, outstretched. Tail short about 1.5 anal body-widths long with 20 striae. Intestine overlapping rectum. Anterior scutellum at about 31% and posterior one at about 81% of the body length from anterior end of the body.

Male: Not found.

Type locality: Haldwani, district Nainital.

Type specimens: Holotype on slide P-144 H. neoformis n. sp./1; paratypes on slides P-144 H. neoformis n. sp./2-3.

Differential diagnosis: Hoplolaimus neoformis n. sp., comes close to H. columbus Sher, 1963 but differs in having conoid lip region with 4 distinct striae; median bulb at the posterior-fourth of esophagus; hemizonid 8-12 striae below the excretory pore; anterior scutellum at 31% from anterior end of the body (lip region hemispheroid with 3 striae; median bulb at posterior-third of esophagus; hemizonid 2-5 striae below the excretory pore; anterior scutellum 34-47% in H. columbus).

SUBFAMILY ROTYLENCHINAE Golden, 1971

GENUS ROTYLENCHUS Filipjev, 1936

Rotylenchus buxophilus Golden, 1956

Locality:

Mussoorie, district Dehradun

GENUS HELICOTYLENCHUS Steiner, 1945

The species of Helicotylenchus commonly occur around paddy in many parts of the World (Sher, 1966). Timm (1966) reported H. multicinctus from East Pakistan while Luc and de Guiran (1960) recorded Helicotylenchus sp. from West Africa. Sher (1966) reports H. dihystera from Malaysia and Hawaii; H. retusus from Hyderabad, India; H. flatus from Brahmanbaria, East Pakistan and Adaturai, Tamil Nadu, India.

In the present study 4 new and 3 known species of this genus have been found from different parts of Uttar Pradesh.

Helicotylenchus indicus Siddiqi, 1963

Localities:

i) Izzatnagar, district Bareilly

ii) Sewlakalan, district Dehradun

iii) Rosa, district Shahjahanpur

Helicotylenchus retusus Siddiqi and Brown, 1964

(Plate: XII, Fig. A-C)

Localities:

i) Mussoorie and Kennuli, district Dehradun

ii) Barwasamerpur, district Hamirpur

iii) Sahrar, district Jhansi

iv) Waheedpur, district Shahjahanpur

v) Aurai, district Varanasi

Remark: The specimens of this species show 3-4 distinct striae on the lip region, this is not mentioned in the original description of the species by Siddiqi and Brown (1964).

Helicotylenchus digitatus Siddiqi and Z. Hussain, 1964

Localities:-

i) Jamalpur, district Aligarh

ii) Siar, district Ballia

iii) Izzatnagar, district Bareilly

iv) Lalaurikhera, district Pilibhit

v) Niranjan, Rosa, Nagla and Lodipur, district Shahjahanpur

Helicotylenchus jhansiensis n. sp.

(Plate: XIII, Fig. A-E)

Dimensions:

Female Paratypes (6): L= 0.74-0.78 mm.; a= 34-41;
b= 7.0-7.5; c= 53-60;
17-20 16-19
V= 61-62 .

Female Holotype: L= 0.80 mm.; a= 32; b= 7.6; c= 53;
17 6
V= 63 .

Description:

Female: Body almost 'C' shaped upon fixation. Transverse striae about 2 μ apart on midbody. Lateral fields marked by 4 incisures, occupying 1/4th the corresponding body-width near middle. The outer incisures are crenate.

Lip region slightly set off, marked with 3-4 striae. Spear 22-23 μ long with rounded basal knobs. Orifice of dorsal esophageal gland 8-12 μ below the spear base. Median bulb of the esophagus at 60-67% of esophageal length from anterior end of body. Esophago-intestinal junction 102-109 μ from anterior end of the body. Excretory pore in the vicinity of esophago-intestinal junction. Hemizonid 0-3 striae above the excretory pore, about 2 striae long.

Vulva a depressed transverse slit. Vagina about half the corresponding body-width long. Gonads amphidelphic, outstretched. Tail hemispheroid with striated terminus, 13-15 μ or about one anal body-width long. Phasmids preanal, 10-12 striae anterior to anus.

Male: Not found.

Type locality: Fields at Moth, district Jhansi.

Type specimens: Collected by Dr. Qaiser H. Baqri in October, 1967. Holotype on slide P-82 H. jhansiensis n. sp./1; paratypes on slides P-82 H. jhansiensis n. sp/2-3.

Differential diagnosis: Helicotylenchus jhansiensis n. sp. comes close to H. retusus Siddiqi and Brown, 1964 but differs in having shorter spear with rounded basal knobs; shorter tail end in the posterior position of median esophageal bulb (spear 25-27 μ, spear knobs anteriorly cupped; tail more than one anal body-width long and the median esophageal bulb situated exactly in middle in H. retusus).

Helicotylenchus implicatus n. sp.

(Plate: XIII, Fig. F-J)

Dimensions:

Female Paratypes (6): L= 0.58-0.66 mm.; a= 26-20; b= 5.8-5.9; c= 32-39; V= 19-20 60-65 16-20 .

Female Holotype: L= 0.60 mm.; a= 27; b= 5.9; c= 32; V= 20 63 16 .

Description:

Female: Body spiral upon fixation. Transverse striae about 1 μ apart on midbody. Lateral fields about 1/5th the body-width near middle; marked with 4 incisures, the outer ones crenate.

Lip region hemispheroid, slightly narrower than the adjoining body, marked with 4-5 striae. Spear 21-23 μ, with anteriorly directed and indented basal knobs. Orifice of dorsal esophageal gland 8-10 μ below the base of spear. Median esophageal bulb at 60-65 of the esophageal length from anterior end of body. Excretory pore anterior to esophago-intestinal valve, above the glandular part of the esophagus, and 99-114 μ from anterior end of body. Hemizonid 2-3 striae anterior to excretory pore, about 3 striae long, opposite nerve ring.

Vulva a depressed transverse slit. Vagina about half the corresponding body-width. Gonads amphidelphic, digonic; ovaries outstretched. Rectum about one anal body-width long, with a distinct overlap of the intestine. Tail 17-18 μ, less than 2 anal body-widths long, ventrally arcuate, bi-digitate. Phasmids at the level of anus or slightly anterior.

Male: Not found.

Type locality: Haldwani, district Nainital.

Type specimens: Holotype on slide P-144 H. implicatus n. sp./1; paratypes on slides P-144 H. implicatus n. sp./2-3.

Differential diagnosis: Helicotylenchus implicatus n. sp., comes close to H. digitatus Siddiqi and Z. Husain, 1964, but differs in having indented spear knobs, shorter tail, anterior location of phasmids and intestine overlapping rectum (spear knobs are rounded, tail over 2 anal body-widths and intestine not overlapping rectum in H. digitatus).

Helicotylenchus acuticaudatus n. sp.

(Plate: XIV, Fig. G-L)

Dimensions:

Female Paratypes (7): L= 0.65-0.78 mm.; a= 32-38; b= 6.1-6.6; c= 45-50; V= 17-20 (60-63) 15-19.

Female Holotype: L= 0.72 mm.; a= 33; b= 6.5; c= 48; V= 19 (61) 19.

Description:

Female: Body almost 'C' shaped upon fixation. Transverse striae less than 2 µ wide on midbody. Lateral fields marked with 4 incisures, occupying less than 1/4th the body-width near middle.

Lip region hemispheroid marked with 5-6 striae. Spear 20-22 µ long, with almost rounded basal knobs. Orifice of

dorsal esophageal gland 10-11 u below the spear base. Median esophageal bulb at about 65-68% of the total esophageal length from anterior end of body, with prominent crescentic valves. Hemizonid 3 striae long, 1-2 striae above the excretory pore.

Vulva a depressed transverse slit. Vagina 10-12 μ long or less than half the corresponding body-width. Gonads amphidelphic, outstretched. Spermatheca spheroid, with sperms. Tail 15-17 μ long, dorsally bent; terminus provided with a long, acute, spine-like ventral projection. Phasmids 3-8 striae above the anus.

Male: Not found.

Type locality: Balakpur, district Pilibhit.

Type specimens: Holotype on slide P-29 H. acuticaudatus n. sp./1; paratypes on slides P-29 H. acuticaudatus n. sp./2-3.

Differential diagnosis: Helicotylenchus acuticaudatus n. sp., comes close to H. digitatus Siddiqi and Z. Hussain, 1964, but differs in the shape of spear knobs; posterior position of dorsal esophageal gland orifice and median esophageal bulb; excretory pore and phasmids; and in the size and shape of tail (spear knobs rounded; dorsal esophageal gland opening 8.5 μ below spear base; median esophageal bulb at about 50% of the total esophageal length; excretory pore in the isthmal region; phasmids at or posterior to the level of anus; tail terminus digit-like in H. digitatus).

Helicotylenchus novus n. sp.

(Plate: XIV, Fig. A-F)

Dimensions:

Female Paratypes (9): L= 0.45-0.58 mm.; a= 23-26; b= 4.5-5.2; c= 30-35; V= 60-65.

Female Holotype: L= 0.46 mm.; a= 24; b= 5.2; c= 35; V= 65.

Description:

Female: Body spirally coiled upon fixation. Transverse striae less than 2 μ apart on midbody. Lateral fields marked with 4 incisures; occupying less than 1/4th the corresponding body-width near middle. The median incisures fuse to form a single incisure just behind the middle of tail, it runs to a short distance disappearing before the outer incisures. The outer incisures are almost crenate.

Lip region slightly set off, marked with 6-6 striae, hemispheroid, moderately sclerotized. Spear 21-22 μ long with anteriorly pointed basal knobs. Orifice of dorsal esophageal gland 7-9 μ below the spear base. Median esophageal bulb spheroid, occupying about half the corresponding body-width, situated at about 61-74% of the total esophageal length from anterior end of body. Excretory pore 87-102 μ from anterior end, slightly anterior to esophago-intestinal valves. Hemizonid 1-2 striae anterior to excretory pore, 2-3 striae long.

Vulva a depressed transverse slit. Vagina about half the corresponding body-width long. Gonads amphidelphic. Tail conoid 14-18 μ or about one anal body-width long. Phasmids at level of anus or 1-3 striae anterior.

Male: Not found.

Type locality: Fields near Railway Station, district Pilibhit.

Type specimens: Holotype on slide P-32 H. novus n. sp./1; paratypes on slides P-32 H. novus n. sp./2-4.

Differential diagnosis: Helicotylenchus novus n. sp., comes close to H. serenus Siddiqi, 1963 from which it differs in having a shorter spear; outer incisures crenate; median incisures fuse near middle of tail and from a single incisure which disappears just before the fusion of outer incisures (spear 27-32 μ; outer incisures smooth; median incisures do not fuse to form single incisure in H. serenus).

FAMILY PRATYLENCHIDAE (Thorne, 1949) Siddiqi, 1963

SUBFAMILY PRATYLENCHINAE Thorne, 1949

GENUS PRATYLENCHUS Filipjev, 1936

Pratylenchus thornei Sher and Allen, 1953

Localities:

i) Rithe, district Meerut

ii) Luksar and Hasanpur, district Saharanpur

Pratylenchus vulnus Allen and Jensen, 1951

Locality:

Lalaurikhera, district Pilibhit

Pratylenchus qaiseri n. sp.

(Plate: XV, Fig. A-D)

Dimensions:

Female Paratypes (8): L= 0.43-0.48 mm.; a= 28-35; b= 5.1-6.0; b'= 3.8-4.3; c= 40-44; V= 72-74.

Female Holotype: L= 0.47 mm.; a= 29; b= 5.6; b'= 4.0; c= 42; V= 73.

Description:

Female: Body slightly bent ventrally posterior to vulva. Transverse striae 1-2 μ apart on midbody. Lateral fields consist of 4 incisures which are smooth and non-areolated.

Lip region narrow, flattened, marked with 2 striae. Spear 14-15 μ long, robust, with well developed basal knobs. Dorsal esophageal gland opening 3-4 μ below the spear base. Median esophageal bulb 45-50 μ from anterior end of the body or at about 60% of total esophageal length. Isthmus long, narrow, enveloped by nerve ring in the middle. Basal glandular part of esophagus forms a short overlap ventrally over the intestine. Esophago-intestinal junction 80-83 μ from anterior end of the body. Excretory pore 6-8 striae anterior to esophago-intestinal junction. Hemizonid just above the excretory pore, 3 striae long. Hemizonion 7 striae below the excretory pore.

Vulva a depressed transverse slit. Vagina about half the corresponding body-width long. Post-uterine sac 25-30 μ or about twice the vulval body-widths long. Rectum slightly longer than one anal body-width. Intestine distinctly overlapping the rectum for about one anal body-width. Tail elongate-conoid, terminus, rounded, 25-32 μ or 2-3 μ anal body-widths long. The number of tail striae varies from 27-30. Phasmids 14-16 striae above tail tip.

Male: Not found.

Type locality: Lalaurikhera, district Pilibhit.

Type specimens: Holotype on slide P-23 P. qaiseri n. sp./1; paratypes on slides P-23 P. qaiseri n. sp./2-3.

Differential diagnosis: Pratylenchus qaiseri n. sp., comes close to P. thornei Sher and Allen, 1963 from which it differs in having only 2 striae on the lip region, shorter spear, longer post-uterine sac, intestine overlapping rectum and striated tail terminus (lip region with 3 striae, spear 17-19 μ, post-uterine sac 1½ vulval body-widths, intestine not overlapping rectum and smooth tail terminus in P. thornei).

The species is named after Dr. Qaiser H. Maqri.

SUBFAMILY RADOPHOLINAE Allen and Sher, 1967

GENUS HIRSCHMANNIELLA Luc and Goodey, 1963

Hirschmanniella oryzae (Soltwedel, 1889) Luc & Goodey, 1963

Localities:

i) Jamalpur, Qasimpur, Bhambhola, Central Dairy Farm, University, Agriculture Farm, Zorub Bagh, district Aligarh.

ii) Nandawan, district Azamgarh

iii) Sisand, district Ballia

iv) Izzatnagar, Collectorbuck Ganj and Ramganga, district Barielly

v) Mussoorie, Niranjanpur, Sewla Kalan and Rishikesh, Dehradun

vi) Kasgunj, district Etah

vii) Sarai Bahadurpur, district Ghazipur

viii) Shahabad and Allahpur, district Hardoi

ix) Raniya and Patara, district Kanpur

x) Chauch colony, district Lakhimpur Kheri

xi) Uldhan, district Meerut

xii) Rohana, Nagal and Salempur, district Muzaffarnagar

xiii) Kichha and Rudrapur, district Nainital

xiv) Balakpur, Saithel and Naugaon, district Pilibhit

xv) Lukaar, Bahadarpur and Kailashpur, district Saharanpur

xvi) Lodhipur, Rasoolpur, Rosa and Misripur, district Shahjahanpur

xvii) Singnapur (Laherpur) district Sitapur

xviii) Sagnakhera and Gyankhera, district Unnao

xix) Aurai, district Varanasi

Hirschmanniella gracilis (de Man, 1880) Luc and Goodey, 1963

(Plate: XVI, Fig. A-E)

Dimensions:

Females (30): L= 1.62 mm. (1.43-2.11 mm.); a= 53 (46-62); b= 13.6 (9-15); b'= 5.6 (4.6-7.6); c= 18 (13-22); V= 24 23 17-27 52 (46-57 19-25).

Males (20): L= 1.70 mm. (1.46-1.80 mm.); a= 54 (50-62); b= 12.6 (10-14.6); b'= 5.7 (5-7.2); c= 18 (15-20); T= 32 (27-40).

Description:

Female: Body slender, ventrally arcuate upon fixation. Transverse striae 2 μ apart on midbody. Lateral fields marked by 4 incisures occupying about 1/3rd of the corresponding body-width near middle. Outer incisures are crenate. Areolation incomplete.

Lip region, flattened with rounded edges, set off from the body by a faint constriction in the cuticle; marked with 3-5 striae, 10-12 μ wide, 3-4 μ high, strongly sclerotized. Excretory pore 110-131 μ from anterior end of the body. Hemizonid 2-4 striae above the excretory pore, 2-3 μ long lens-like, supplied with a nerve from nerve ring. Hemizonion not observed. Spear 20-24 μ long stout, with rounded basal knobs. Metenchium and telenchium almost equal in length. Orifice of dorsal esophageal gland 2-3 μ below the spear base. Procorpus long slender tube with narrow lumen. Median esophageal bulb ovate, 80-95 μ, from anterior end of body, 12-15 μ wide with well developed crescentic valves. Isthmus short narrow tube enveloped by nerve ring at its middle. Nerve ring 118-140 μ from the anterior end. Basal glandular part of the esophagus forming a a long ventral overlap over the intestine. Gland nuclei large and prominent. The ducts arising from these glands open in the lumen of esophagus at different levels. The dorsal gland opens in procorpus close spear base while the two subventrals at the base of crescentic valves in the median bulb. Just before openning into the lumen of esophagus all these ducts form ampullae.

Vulva a depressed transverse slit; vagina at right angle to the body axis 10-12 μ long. Ovaries paired, amphidelphic, outstretched provide with 37 (27-43) oocytes arranged in a single row except in the zone of multiplication. Oviduct large slender tube terminating into an elongated and somewhat spherical spermatheca, usually filled with sperms. Uterus with a narrow quadricolumella and a broader uterine part. Tail 4-6 anal body-widths long, uniformly tapering to a pointed terminus provided with a mucro. Phasmids located in the posterior half of tail at different levels.

Male: Testis single, anteriorly outstretched occupying about 27-42% of the total body length, confined to the posterior half of the body. Germ cells 49-59, arranged in a single row except in the germination zone. Vas deferens with proximal glandular and terminal muscular part terminating into narrow ejaculatory duct. Spicules 32-36 μ with distinct head, neck and shaft. Gubernaculum 9-12 μ. Caudal alae well developed with crenate margins, not enveloping the tail completely, placed asymmetrically, terminating above or below the phasmids.

Locality: Jogipura, district Bijnor.

Diagnosis: Hirschmanniella gracilis is close to H. spinicaudata (Schuurmans Stekhoven, 1944) Luc & Goodey, 1963, but can be distinguished by the flattened lip region, shorter spear and inconspicuous overlap of the intestine over rectum.

Hirschmanniella timmi n. sp.

(Plate: XVII, Fig. A-M)

Dimensions:

Female Paratypes (70): L= 1.27 mm. (1.19-1.36 mm.);
a= 51 (40-59); b= 11.0 (10.1-13.8);
b'= 4.7 (3.8-5.6); c= 20 (17-23);
V= 23 (21 20-26 18-25).
54 (51-56)

Male Paratypes (30): L= 1.24 mm. (1.20-1.36 mm.);
a= 52 (43-59); b= 12.0 (10.5-14.0);
b'= 4.8 (4.4-5.1); c= 19 (17-21);
T= 33 (30-37).

Female Holotype: L= 1.38 mm.; a= 60; b= 12.5; b'= 6.5;
c= 21; V= 28 20 .
56

Description:

Female: Body slightly ventrally arcuate or assuming a 'C' shape upon fixation. Outer cuticle transversely striated, striae about 2 μ apart on midbody; inner cuticle faintly striated. Lateral fields marked by 4 incisures of which outer ones are crenate. They arise as single line about the level of spear base, the second and third incisures appear in the middle of procorpus and the fourth one just above the nerve ring. The width of lateral fields near midbody is approximately one-third. Areolation incomplete.

Lip region set off from the body by a faint depression, marked with 5-6 striae. Excretory pore just behind the

esophago-intestinal valve, 110-124 μ from anterior end of body. Hemizonid 2-3 body striae long, situated 0-2 striae above excretory pore. Hemizonion 26-50 μ behind the excretory pore, about one striae long. Spear 17 μ (16-19 μ) long, with rounded basal knobs. Orifice of dorsal esophageal gland 2-3 μ behind the spear base. Median esophageal bulb 73-77 μ from anterior end of body. Nerve ring 87-95 u from anterior end enveloping middle of isthmus.

Vulva a depressed transverse slit. Vagina less than half of corresponding body-width. Conads amphidelphic, outstretched. Oviducts with elongate-spheroid spermatheca filled with sperms. Ovaries with 30-40 oocytes. Tail 3.5-5.0 anal body-widths long, with a distinct mucro which is accompanied by a ventral notch. Phasmids 20-35 μ above tail tip.

Male: Spicules 22-26 μ. Gubernaculum 7-9 μ. Caudal alae 43-81 μ long, arise anterior to spicules, the two wings originate as well as terminate at different levels. They terminate posterior to the level of phasmids. Tail as in female.

Type locality: Fields near Railway Station, Pilibhit, district Pilibhit.

Additional localities: The new species was also recorded from the following localities in Uttar Pradesh, India: Balakpur, Pilibhit; Malihabad, Lucknow; Siar, Ballia; and Bhanauliya, Bareilly.

Type specimens: Holotype on slide P-32 H. timmi n. sp./1; paratypes on slides P-32 H. timmi n. sp./2-20.

Differential diagnosis: The new species comes close to H. maxicana Sher, 1968; H. caudacrena Sher, 1968 and H. marina Sher, 1968, but differs from them in having a distinct mucro as well as a ventral notch (these three species possess a ventral notch but there is no distinct mucro). In addition, it differs from H. maxicana in having smaller body, distinct striae on the head, and lateral fields incompletely areolated. From H. marina it further differs in having smaller body, less conspicuous glandular lobes of esophagus, in having excretory pore below the level of esophago-intestinal valve and lateral fields with areolation. From H. caudacrena it differs in having more striae on the head, posterior position of excretory pore and shorter spicules. It also comes close to H. oryzae (Soltwedel, 1889) Luc & Goodey, 1963 but differs in having coarse body striae; a distinct hemizonion and a ventral notch on tail in addition to mucro (body striae not very coarse; hemizonion absent; tail with a ventral mucro in H. oryzae).

The species is named after Father R.W. Timm.

Hirschmanniella indica n. sp.

(Plate: XVIII, Fig.A-M)

Dimensions:

Female Paratypes (10): L= 1.80 mm. (1.62-2.03 mm.);
a= 47 (41-58); b= 12.1 (12.0-14.6);
b'= 5.2 (4.6-5.7); c= 17 (15-19);
V= 22 (21-26) 17 (18-24).

Male Paratypes (8): L= 1.62-1.87 mm.; a= 40-58;
b= 12.1-13.8; b'= 3.9-5.7; c= 16-19;
T= 26-37.

Female Holotype: L= 1.75 mm.; a= 44; b= 10.6; b'= 6.8;
c= 17; V= 22 (20).

Description:

Female: Body ventrally arcuate often 'C' shaped upon fixation. Transverse striae over 2 μ apart near midbody. Lateral fields marked with 4 incisures, non-areolated, 1/3rd body-width wide near middle.

Lip region marked with 4-5 striae slightly marked off from the body by a constriction in cuticle. Excretory pore in front of the esophago-intestinal junction or slightly anterior, 120-146 μ from anterior end of body. Hemizonid 0-4 μ above the excretory pore, 2-3 striae long. Spear 23 μ (22-23 μ), with rounded basal knobs. Orifice of the dorsal esophageal gland 2-3 μ from base of spear. Median esophageal bulb 80-105 μ from anterior end of body. Nerve ring 102-124 μ

from anterior end.

Vulva transverse. Vagina 12-14 μ. Spermatheca rounded, or slightly elongated with or without sperms. Ovaries with 37-43 oocytes. Intestine distinctly overlapping the rectum. Tail 4-6 anal body-widths long, with a blunt terminus accompanied by a mucro, 1-3 μ long and sometimes inconspicuous. Phasmids 25-43 μ above tail tip.

Male: Spicules 32-34 μ. Gubernaculum 8-10 μ. Caudal alae 88-110 μ long. Tail as in female.

Type locality: Fields at Barwe Sagar, district Jhansi.

Additional localities: The new species was also recorded from the following two places: Kanmuli, Dehradun; and fields near Coca Cola Plant, Meerut.

Type specimens: Collected in October, 1967 by Dr. Qaiser H. Baqri; holotype female on slide P-85 H. indica n. sp./1; paratypes on slides P-85 H. indica n. sp./2-8.

Differential diagnosis: The new species comes close to the type species, H. spinicaudata (Sch. Stek., 1944) Luc and Goodey 1963; H. gracilis (de Man, 1880) Luc and Goodey, 1963 and H. mucronata (Das, 1960) Luc and Goodey, 1963. It differs from H. spinicaudata in having a shorter body and a smaller spear. From H. gracilis it can be differentiated in having hemispheroidal lip region and distinct overlap of the intestine over rectum. From H. mucronata it differs in having

shorter spear; non-areolated lateral fields and prominent overlap of the intestine over rectum; hemizonid and excretory pore anterior to esophago-intestinal valve (spear 24-29 μ; lateral fields areolated in posterior half of the body; intestine slightly overlapping rectum; and hemizonid and excretory pore posterior to esophego-intestinal valve in H. mucronata).

SUPERFAMILY CRICONEMATOIDEA (Taylor, 1936) Geraert, 1966

FAMILY CRICONEMATIDAE (Taylor, 1936) Thorne, 1949

SUBFAMILY CRICONEMATINAE Taylor, 1936

GENUS HEMICRICONEMOIDES Chitwood and Birchfield, 1957

Hemicriconemoides squamosus (Cobb, 1913) Siddiqi and Goodey, 1963

Localities:

i) Haldwani, district Nainital

ii) Sewla Kelan, district Dehradun

FAMILY PARATYLENCHIDAE (Thorne, 1949) Raski, 1962

SUBFAMILY PARATYLENCHINAE Thorne, 1949

GENUS PARATYLENCHUS Micoletzky, 1922

The specimens of Paratylenchus recovered from paddy fields in Uttar Pradesh yielded 2 known and one new species.

Paratylenchus aculentus Brown, 1959

Locality:

Misrik, district Sitapur

Paratylenchus nainianus, Edward and Misra, 1964

Locality:

Rose, district Shahjahanpur

Paratylenchus oryzae n. sp.

(Plate: XIX, Fig. A-E)

Dimensions:

Female Paratypes (17): L= 0.34 mm. (0.30-0.43 mm.);
a= 19 (17-22); b= 3.4 (3.0-3.8);
c= 15 (13-18); V= 81 (78-85).

Female Holotype: L= 0.32 mm.; a= 19; b= 34; c= 15;
V= 83.

Description:

Female: Body ventrally arcuate upon fixation. Transverse striae about 1 μ apart on midbody. Lateral fields marked with 2 incisures.

Lip region hemispheroid, continuous with the body contour. Spear 43-48 μ with anteriorly flattened basal knobs. Dorsal esophageal gland opening 8-12 μ below the spear base. Excretory pore 70-90 μ from anterior end of the body. Nerve ring 80-105 μ from anterior end. Hemizonid at or slightly above the excretory pore.

Vulva depressed, transverse, slit-like. Vagina anteriorly directed, about one-half the vulval body-width long. Ovary prodelphic, outstretched; spermatheca elongate, about twice the corresponding body-widths long, filled with sperms. Post-uterine sac slightly shorter than corresponding body-width. Tail 15-22 u or 2 anal body-widths long, convex-conoid with 15-20 striae. Phasmids anterior to middle of tail.

Male: Not found.

Type locality: Abahin (Kanth), district Shahjahanpur.

Type specimens: Holotype on slide P-39 P. oryzae n. sp./1; paratypes on slides P-39 P. oryzae n. sp./2-6.

Differential diagnosis: Paratylenchus oryzae n. sp., comes close to P. micoletzkyi Edward et al., 1967, but differs in having smoothly rounded lip region without raised papillae, posteriorly located dorsal esophageal gland opening and excretory pore anterior to nerve ring (lip region truncated, with raised papillae, dorsal esophageal gland opening close to spear base and excretory pore posterior to nerve ring in P. micoletzkyi).

SUPERFAMILY NEOTYLENCHOIDEA (Thorne, 1941) Jairajpuri and Siddiqi, 1969

FAMILY NEOTYLENCHIDAE (Thorne, 1941) Thorne, 1949

SUBFAMILY NEOTYLENCHINAE Thorne, 1941

GENUS HEXATYLUS T. Goodey, 1926

Hexatylus viviparus T. Goodey, 1926
(Plate: XX, Fig. A-H)

During present investigations several specimens of H. viviparus have been collected. A brief description of the material is given below:

Dimensions:

Females (9): L= 0.89-1.25 mm.; a= 21-42; b= 8.4-11.6; c= 15-20; V= 73-82.

Description:

Female: Body almost straight upon fixation. Transverse striae about 1-2 μ apart on midbody. Lateral fields marked with 4 incisures.

Lip region cap-like. Spear 9-11 μ long, knobs furcated at base. Strengthening rings around the spear distinct. Procorpus, metacorpus and isthmus fused. Dorsal esophageal gland opening 6-8 μ below the spear base. Basal glandular part of esophagus forms a dorsal overlap over the intestine. Excretory pore posterior to nerve ring. Deirids at level of

excretory pore. Hemizonid at or slightly above the excretory pore, 2-3 striae long. Nuclei of the intestinal cells distinctly visible anteriorly.

Vulva slit-like. Vagina anteriorly directed, about one-half the vulval body-width long. Gonad prodelphic, outstretched. Rectum about one anal body-width long. Tail elongate conoid. Phasmids anterior to middle of tail, 46-48 μ from tail tip.

Localities:

i) Izzatnagar, district Bareilly

ii) Niranjanpur, district Dehradun

GENUS DELADENUS Thorne, 1941

Deladenus durus (Cobb, 1922) Thorne, 1941

Locality:

Siar, district Ballia

FAMILY PAURODONTIDAE (Thorne, 1941) Massey, 1967

SUBFAMILY PAURODONTINAE Thorne, 1941

GENUS PAURODONTUS Thorne, 1941

Paurodontus gracilis Thorne, 1941

Locality:

Balakpur, district Pilibhit

FAMILY NOTHOTYLENCHIDAE (Thorne, 1941) Jairajpuri and Siddiqi, 1969

SUBFAMILY NOTHOTYLENCHINAE Thorne, 1941

GENUS NOTHOTYLENCHUS Thorne, 1941

Nothotylenchus drymocolus Ruhm, 1956

Locality:

Malihabad, district Lucknow

Nothotylenchus acris Thorne, 1941

Localities:

i) Jogipura, district Bijnor

ii) Sewlakhurd, district Dehradun

Nothotylenchus innuptus Andrassy, 1961

Localities:

i) University Agriculture Farm, district Aligarh

ii) Kanth, district Shahjahanpur

Nothotylenchus basiri Khan, 1965

Localities:

i) Izzatnagar, district Bareilly

ii) Rosa, district Shahjahanpur

Nothotylenchus acutus Khan, 1965

Localities:

i) Sier, district Ballia

ii) Sewlakhurd, district Dehradun

iii) Lodhipur, district Shahjahanpur

Nothotylenchus acuticaudatus n. sp.

(Plate: XXI, Fig. A-C)

Dimensions:

Female Paratypes (6): L= 0.41-0.63 mm.; a= 41-44; b= 5.3-5.6; c= 6-7; V= 62-64.

Female Holotype: L= 0.43 mm.; a= 43; b= 5.6; c= 6; V= 62.

Description:

Female: Body ventrally arcuate upon fixation. Transverse striae about 1 μ apart on midbody. Lateral fields marked with 4 incisures 5-7 μ wide or about one-third the corresponding body-width near middle.

Lip region truncate, slightly set off from body, weakly sclerotized. Spear 8-9 μ long with small anteriorly slopping basal knobs. Opening of dorsal esophageal gland 5-7 μ below the spear base. Excretory pore posterior to nerve ring, 90-105 μ from the anterior end of body, at the beginning of basal bulb. Hemizonid 2-3 striae anterior to excretory pore, about 2 striae long.

Vulva depressed transverse slit-like. Vagina one-half vulval body-width long. Ovary prodelphic, outstretched. Spermatheca oval, filled with sperms. Post-uterine sac less than one vulval body-width long. Tail 95-115 μ long, terminus acute, slightly less than the vulva-anus distance or 13-15 anal body-widths.

Male: Not found.

Type locality: Ritha, district Meerut.

Type specimens: Holotype on slide P-141 N. acuticaudatus n. sp./1; paratypes on slides P-141 N. acuticaudatus n. sp./2-3.

Differential diagnosis: Nothotylenchus acuticaudatus n. sp., comes close to N. antricolus Andrássy, 1961 but differs in having spindle shaped metacorpus, pyriform basal bulb, and in having a tapering truncated lip region.

GENUS SAKIA S.H. Khan, 1964

Sakia indica (I. Husain and A.M. Khan, 1965) E. Khan, Mathur, Nand and Prasad, 1968

Localities:

i) Rohana, Salempur, district Muzaffarnagar

ii) Laksar, Kailashpur, district Saharanpur

Sakia oryzae n. sp.

(Plate: XXI, Fig. D-I)

Dimensions:

Female Paratypes (8): L= 0.51-0.60 mm.; a= 50-55; b= 5.3-6.0; c= 3-4; V= 59-62.

Female Holotype: L= 0.53 mm.; a= 53; b= 5.3; c= 4; V= 60.

Description:

Female: Body almost straight upon fixation. Cuticle faintly striated, striae less than 1 μ apart on midbody. Lateral fields marked with 4 incisures occupying about 1/4th the corresponding body-width near middle.

Lip region smooth, confluent with the body. Labial disc conspicuous. Spear 7-9 μ long with anteriorly slopping basal knobs. Dorsal esophageal gland opening 2-3 μ below the spear base. Esophagus with a narrow procorpus, slightly swollen valveless metacorpus, and pyriform basal bulb. Isthmus long, enveloped by nerve ring anterior to middle. Excretory pore 12-20 μ posterior to the level of nerve ring. Terminal excretory duct wide, with strongly sclerotized lumen. Hemizonid 2-3 striae long, at or slightly above the level of excretory pore, 70-90 μ from anterior end of body.

Vulva a prominent, wide transverse slit. Vagina about one-half the vulval body-width long. Ovary prodelphic,

outstretched. Post-uterine sac 10-12 μ or about one vulval body-width long. Tail long filiform, 110-130 μ long or 24-28 anal body-widths long.

Male: Not found.

Type locality: Haldwani, district Nainital.

Type specimens: Holotype on slide P-142 S. oryzae n. sp./1; paratypes on slides P-142 S. oryzae n. sp./2-3.

Differential diagnosis: Sakia oryzae n. sp. comes close to S. indica but differs from it in having smaller spear, posteriorly located vulva and a prominent labial disc (spear 9-11 μ, vulva 52-57% and inconspicuous labial disc in S. indica).

SUBFAMILY BOLEODORINAE E. Khan, 1966

GENUS BOLEODORUS Thorne, 1941

Boleodorus thylactus Thorne, 1941

Localities:

i) Izzatnagar, district Bareilly

ii) Mussoorie, district Dehradun

Boleodorus impar E. Khan, 1966

Locality:

Luksar, district Saharanpur

FAMILY ECPHYADOPHORIDAE (Skarbilovich, 1949) Skarbilovich, 1959

SUBFAMILY ECPHYADOPHORINAE Skarbilovich, 1949

GENUS ECPHYADOPHORA de Man, 1921

Ecphyadophora tenuissima de Man, 1921

Localities:

i) Jamalpur, district Aligarh

ii) Luksar, district Saharanpur

SUBORDER APHELENCHINA Geraert, 1966

SUPERFAMILY APHELENCHOIDEA (Fuchs, 1937) Thorne, 1949

FAMILY APHELENCHIDAE (Fuchs, 1937) Steiner, 1949

SUBFAMILY APHELENCHINAE (Fuchs, 1937) Schuurmans Stekhoven & Teunissen, 1938

GENUS APHELENCHUS Bastian, 1865

Aphelenchus avenae Bastian, 1865

Localities:

i) Jamalpur, district Aligarh

ii) Sisar, district Ballia

iii) Sewla Kalan and Rishikesh, district Dehradun

iv) Salempur and Kali Nadi bank fields, district Muzaffarnagar.

v) Jarandanara, Rithe and Kharkhunda, district Meerut
vi) Haldwani, district Nainital
vii) Bahadurpur, Luksar and Kailashpur, district Saharanpur
viii) Banthra, Hathhaura and Rose, district Shahjahanpur

Aphelenchus mashhoodi n. sp.

(Plate: XXII, Fig. A-E)

Dimensions:

Female Paratypes (15): L= 0.84 mm. (0.78-0.89 mm.); a= 41 (37-43); b= 7.6 (7.3-8.1); b'= 4.2 (4.1-4.5); c= 22 (21-25); V= 78 (76-79).

Female Holotype: L= 0.80 mm.; a= 40; b= 7.9; b'= 4.4; c= 25; V= 78.

Description:

Female: Body almost straight upon fixation. Transverse striae 1-2 μ on midbody. Lateral fields marked by 8 incisures which are very fine but distinctly visible. The number of incisures reduces to 7 on tail.

Lip region rounded continuous with body contour. Spear 15-17 μ long without basal knobs. Median bulb ovoid, filling almost the entire body space. The glandular part of esophagus 180-220 μ . from anterior end of the body, lobe-like, overlapping the intestine. Excretory pore well posterior

to nerve ring. Hemizonid 2-5 striae below the excretory pore, 110-125 μ from anterior end of the body. Hemizonion 25-30 μ posterior to hemizonid.

Vulva a depressed transverse slit. Vagina about half the vulval body-width long, directed anteriad. Ovary prodelphic, outstretched, oocytes arranged in a single row except in the zone of multiplication. Spermatheca indistinct. Post-vulval sac about one body-width at vulva. Rectum 27-32 μ, more than 2 anal body-widths long. Tail 32-45 μ, about 3 anal body-widths long.

Male: Not found.

Type locality: Ritha, district Meerut.

Type specimens: Holotype on slide P-141 A. mashhoodi n. sp./1; paratypes on slides P-141 A. mashhoodi n. sp./2-4.

Differential diagnosis: Aphelenchus mashhoodi n. sp., comes close to type species A. avenae Bastian, 1865, from which it differs in having longer rectum, longer tail and shorter post-uterine sac (rectum one anal body-width long, post-uterine sac one vulval body-width long, tail slightly longer than one anal body-width in A. avenae). It also comes close to A. eremitus having 8 incisures in lateral fields and a short esophageal gland overlap but differs in having longer rectum and longer tail (rectum about one anal body-width and tail about 1½ anal body-widths long in A. eremitus).

The species is named after Professor S. Mashhood Alam, Head, Department of Zoology, Aligarh Muslim University.

FAMILY APHELENCHOIDIDAE (Skarbilovich, 1947) Paramonov, 1953

SUBFAMILY APHELENCHOIDINAE Skarbilovich, 1947

GENUS APHELENCHOIDES Fischer, 1894

Aphelenchoides aligarhiensis Siddiqi, I. Husain and A.M. Khan, 1967

Localities:

i) Jamalpur, district Aligarh
ii) Siar, district Ballia
iii) Izzatnagar, district Bareilly
iv) Jogipura, district Bijnor
v) Rosa, district Shahjahanpur

Aphelenchoides bicaudatus (Imamura, 1931)
Filipjev and Schuurmans Stekhoven, 1941

Localities:

i) Ramganga river bank fields, district Bareilly
ii) Partapur, district Meerut
iii) Rohana, district Muzaffarnagar
iv) Rosa, district Shahjahanpur

Aphelenchoides delhiensis Chawla, Bhamburkar, E. Khan & Prasad, 1968

Localities:

i) Mussoorie and Niranjanpur, district Dehradun
ii) Kailashpur and Rishikesh, district Saharanpur

GENUS SEINURA Fuchs, 1931

Seinura basiri n. sp.

(Plate: XXIII, Fig. B-E)

Dimensions:

Female Paratypes (8): L= 0.43-0.52 mm.; a= 30-34; b= 4.0-4.6; c= 7-9; V= 56-61.

Female Holotype: L= 0.44 mm.; a= 31; b= 4.4; c= 7; V= 60.

Description:

Female: Body strongly ventrally arcuate upon fixation. Lateral incisures inconspicuous.

Lip region slightly marked off. Spear 15-17 μ long. Median bulb of esophagus oblong. Valvular apparatus of median bulb posterior to middle. Glandular part of esophagus overlaps the intestine dorsally.

Vulva a depressed transverse slit. Vagina about half the vulval body-width long, directed anteriad. Gonads prodelphic, outstretched. Post-uterine sac about 3 times the vulval body-widths long. Rectum 10-12 μ or about 1 anal body-width long. Tail 55-68 μ or 6-7 anal body-widths long, elongate, tapering to a rounded tip.

Male: Not found.

Type locality: Niranjanpur, district Dehradun.

Type specimens: Holotype on slide P-6 S. basiri n. sp./1; paratypes on slides P-6 S. basiri n. sp./2-4.

Differential diagnosis: Seinura basiri n. sp., comes close to S. tenuicauda (de Man, 1895) J.B. Goodey, 1960 and S. steineri Mechler and Taylor, 1965, but differs from both these species in having shorter body and inconspicuous basal knobs of the spear and posteriorly located vulva.

The species is named after late Professor M.A. Basir.

Seinura indica n. sp.

(Plate: XXIII, Fig. A, F-J)

Dimensions:

Female Paratypes (8): L= 0.39-0.47 mm.; a= 29-32; b= 5.7-6.9; b'= 3.2-3.7; c= 6-7; V= 61-63.

Male Paratypes (9): L= 0.36-0.44 mm.; a= 29-31; b= 5.3-5.7; b'= 3.3-3.7; c= 13-14; T= 44-54.

Female Holotype: L= 0.41 mm.; a= 29; b= 5.8; b'= 3.5; c= 6; V= 61.

Description:

Female: Body ventrally arcuate upon fixation. Cuticle faintly striated. Lateral incisures not prominent.

Lip region set off, with 4-6 striae. Spear 13-14 μ long. Nerve ring 60-74 μ from anterior end of body. Excretory pore anterior to nerve ring. Hemizonid just below the level of nerve ring. Basal part of esophagus forming a distinct overlap of the intestine dorsally.

Vulva a depressed transverse slit. Vagina less than one-half the body-width at vulva. Gonad prodelphic, outstretched. Spermatheca rounded, filled with sperms. Post-uterine sac slightly shorter than 2 vulval body-widths. Tail 48-68 μ long, arcuate, tapering, with a T-shaped spike at the terminus. Rectum 2 anal body-widths long.

Males: Tail comperatively shorter than female, conoid, with a long spine-like projection or spike. Spicules separate, ventrally curved with a small rostrum and ventral flange, 15-17 μ medially. Papillae 4 pairs; one pair adanal, 3 pairs post-anal.

Type locality: Mohammadi, district Lakhimpur Kheri.

Type specimens: Holotype on slide P-38 S. indica n. sp./1; paratypes on slides P-38 S. indica n. sp./2-4.

Differential diagnosis: Seinura indica n. sp., differs from all the species of the genus in having a spike on the female tail, while in other species of the genus the spike, if present, is found only on the male tail terminus.

ORDER DORYLAIMIDA PEARSE, 1942

SUBORDER DORYLAIMINA (Chitwood, 1933) Pearse, 1936

SUPERFAMILY DORYLAIMOIDEA (de Man, 1876) Thorne, 1934

FAMILY DORYLAIMIDAE de Man, 1876

SUBFAMILY DORYLAIMINAE (de Man, 1876) Filipjev, 1918

GENUS THORNENEMA Andrassy, 1959

Thorneneme mauritianum (Williems, 1959) Baqri and Jairajpuri, 1968

Several specimens of T. mauritianum have been collected from Lakarsanda (Salempur), district Muzaffarnagar.

SUBFAMILY PUNGENTINAE Siddiqi, 1969

GENUS PUNGENTUS Thorne and Swanger, 1936

Pungentus angulatus Jairajpuri and Baqri, 1966

Several specimens of P. angulatus have been collected from Hathauria, district Shahjahanpur.

SUBFAMILY DISCOLAIMINAE Siddiqi, 1969

GENUS DISCOLAIMIUM Thorne, 1939

Discolaimium bulbiferum (Cobb, 1906) Timm and Bhuiyan, 1963

Localities:

i) Izzatnagar, district Bareilly

ii) Lalaurikhera, district Pilibhit

Discolaimium monhystera Siddiqi, 1965

Several females of D. monhystera have been collected from paddy fields near Central Dairy Farm, district Aligarh.

Discolaimium arcuatum Z. Husain and Siddiqi, 1967

Several specimens of D. arcuatum have been collected from Baragaon, district Unnao.

Discolaimium unum Baqri and Jairajpuri, 1968

Localities:

i) Sewlakhurd and Pithuwala, district Dehradun

ii) Luksar, Islamia College Field, Pathria, Kailashpur and Gopalpur, district Saharanpur.

Discolaimium indicum n. sp.

(Plate: XXIV, Fig. A-E)

Dimensions:

Female Paratypes (7): L= 1.19-1.32 mm.; a= 31-35; b= 4.0-4.7; c= 50-56; V= 53-58.

Female Holotype: L= 1.26 mm.; a= 33; b= 4.5; c= 50; V= 54.

Description:

Female: Body slightly ventrally arcuate upon fixation. Cuticle smooth.

Lip region distinctly set off. Cephalic papillae raised. Amphids cup-like about half the lip-width wide, 4-5 μ from anterior end of the body. Sensillar pouches 20-22 μ from anterior end of the body. Spear 15-16 μ long; aperture slightly less than half the spear length. Spear extensions 20-22 μ long. Spear guiding ring 7-8 μ from anterior end of the body. Nerve ring 268-281 μ from anterior end. Basal expanded part of esophagus 36-38% of the esophageal length.

Vulva transverse slit-like. Vagina 15-16 μ or slightly less than half the corresponding body-width long. Ovaries amphidelphic, reflexed. Oocytes in multiple rows. Prerectum 50-75 μ, or 2-3 anal body-widths long. Rectum 30-35 μ or about 1 anal body-width long. Tail slightly shorter than the body-width at anus.

Male: Not found.

Type locality: Jamaur, district Shahjahanpur.

Type specimens: Holotype on slide P-46 D. indicum n. sp./1; paratypes on slides P-46 D. indicum n. sp./2-4.

Differential diagnosis: Discolaimium indicum n. sp., comes close to D. simplex Siddiqi, 1965 and D. conura Thorne, 1939. From D. simplex it differs in having stouter body; shorter spear and inconspicuous lateral glandular organs (a= 40-48; spear 19-20 u; and 67 prominent glandular organs in D. simplex). From D. conura it differs in having longer spear and longer prerectum (spear shorter than the lip-width; prerectum about one anal body-width long in D. conura).

GENUS DISCOLAIMUS Cobb, 1913

Discolaimus similis Thorne, 1939

Localities:

i) Moth, district Jhansi

ii) Abahim (Kanth), district Shahjahanpur

Discolaimus brevis Siddiqi, 1964

Localities:

i) Paddy fields near Central Dairy Farm, district Aligarh

ii) Sisr, district Ballia

SUBFAMILY NORDIINAE Jairajpuri and A.H. Siddiqi, 1964

GENUS LONGIDORELLA Thorne, 1939

Longidorella parva Thorne, 1939

Localities:

i) Jogipura, district Bijnor

ii) Lakersande, district Muzaffarnagar

FAMILY APORCELAIMIDAE Heyns, 1965

GENUS APORCELAIMELLUS Heyns, 1965

Aporcelaimellus obtusicaudatus (Bastian, 1865) Altherr, 1968

Locality:

Jamalpur and Bhambole, district Aligarh

GENUS SECTONEMA Thorne, 1930

Sectonema procta Jairajpuri and Baqri, 1966

Locality:

Nangla, district Shahjahanpur

FAMILY LONGIDORIDAE (Thorne, 1935)

Meyl, 1961

GENUS LONGIDORUS (Micoletzky, 1922) Filipjev, 1934

Longidorus brevicaudatus (Schuurmans Stekhoven, 1951) Thorne, 1961

Localities:

i) Jamalpur, district Aligarh

ii) Pathria (Luksar), district Saharanpur

iii) Mahmoodpur Sarsia, district Sitapur

iv) Abahin (Kanth), district Shahjahanpur

GENUS XIPHINEMA Cobb, 1913

Xiphinema americanum Cobb, 1913

Localities:

i) Rosa, district Shahjahanpur

ii) Mallapur, district Sitapur

GENUS PARALONGIDORUS Siddiqi, Hooper and Khan, 1963

Paralongidorus citri (Siddiqi, 1959) Siddiqi, Hooper and Khan, 1963

Locality:

Uldhan, district Meerut

Paralongidorus parvus n. sp.

(Plate: XXIV, Fig. C-J)

Dimensions:

Female Paratypes (7): L= 2.35-2.98 mm.; a= 67-72; b= 9.6-10.3; c= 101-110; V= 67-73.

Female Holotype: L= 2.72 mm.; a= 70; b= 10.0; c= 104; V= 70.

Description:

Female: Body ventrally arcuate upon fixation. Cuticle smooth. Lateral chords indistinct.

Lip region distinctly set off from body. Amphids about lip-width wide. Spear 60-65 μ long; spear extensions 23-25 μ long. Guiding ring about 23-30 μ from anterior end of body. Nerve ring at 117-135 μ from anterior end. Basal expanded part of esophagus about 1/4th the esophageal length. Cardia very small, discoid.

Vulva transverse, slit-like in appearence. Gonads amphidelphic. Ovaries reflexed; oocytes arranged in multiple rows. Prerectum 20-30 μ or about 1 anal body-width long. Tail 30-35 μ long or slightly longer than the body-width at anus, more or less hemispheroid.

Male: Not found.

Type locality: Mohammadi, district Lakhimpur Kheri.

Type specimens: Holotype on slide P-36 P. parvus n. sp./1; paratypes on slides P-36 P. parvus n. sp./2-5.

Differential diagnosis: Paralongidorus parvus n. sp., comes close to P. sali Siddiqi et al., 1969 and P. microlaimus Siddiqi, 1964 in having smaller body. From the former it differs in having set off lip region, smaller esophagus, smaller spear and differently shaped amphids (Lip region not set off; b= 5.2-7.4; spear 98-107 u in P. sali). From P. microlaimus it differs in having set off lip region; unflanged spear extensions; and shorter tail (lip region not set off, flanged spear extensions and tail more than one anal body-width long in P. microlaimus).

FAMILY TYLENCHOLAIMIDAE (Filipjev, 1934) Siddiqi, 1969

SUBFAMILY TYLENCHOLAIMINAE Filipjev, 1934

GENUS TYLENCHOLAIMUS de Man, 1876

Tylencholaimus obscurus Jairajpuri, 1965

Localities:

i) Izzatnagar, district Bareilly
ii) Kanauli, district Dehradun
iii) Fields near Coca Cola Distillary, district Meerut
iv) Accatair (Luksar), district Saharanpur

SUPERFAMILY NYGOLAIMOIDEA (Thorne, 1935) de Coninck, 1965

FAMILY NYGOLAIMIDAE (Thorne, 1935) Meyl, 1960

GENUS NYGOLAIMUS Cobb, 1913

Nygolaimus aquaticus Thorne, 1930

Localities:

i) Jamalpur and Qasimpur, district Aligarh
ii) Sier and Sisaad, district Ballia
iii) Kannuli, Niranjanpur, Pithuwala and Mussoorie, district Dehradun
iv) Partapur and Field near Coca Cola Distillary, district Meerut
v) Lalaurikhera and Railway Colony, district Pilibhit
vi) Gopalpur, Hasanpur, Kailashpur, Nagal, Shyamapur and Accatair (Luksar), district Saharanpur
vii) Rosa, Balliya, Baroberia and Sarai Khas, district Shahjahanpur

SUPERFAMILY ACTINOLAIMOIDEA Thorne, 1967

FAMILY NEOACTINOLAIMIDAE Thorne, 1967

GENUS NEOACTINOLAIMUS Thorne, 1967

Neoactinolaimus agilis Thorne, 1967

Localities:

i) Jamalpur, district Aligarh

ii) Izzatnagar, district Bareilly

iii) Kanmuli and Mussoorie, district Dehradun

iv) Accatair (Luksar), district Saharanpur

v) Banketra, Balliya and Beroberia, district Shahjahanpur

vi) Gyanpur, district Varanasi

SUPERFAMILY LEPTONCHOIDEA (Thorne, 1935) V. R. Ferris, 1971

FAMILY LEPTONCHIDAE Thorne, 1936

GENUS LEPTONCHUS Cobb, 1920

Leptonchus granulosus Cobb, 1920

Localities:

i) Jamalpur, district Aligarh

ii) Niranjanpur, district Dehradun

iii) Barwe Sagar, district Jhansi

iv) Malihabad, district Lucknow

v) Kharkhunda, district Meerut

vi) Agriculture Farm, Islamia Inter College, district Saharanpur

Leptonchus magnus n. sp.

(Plate: XXV , Fig. A-D)

Dimensions:

Female Paratypes (13): L= 2.20 mm. (2.00-2.43 mm.); a= 52 (48-54); b= 6.5 (6.2-7.0); c= 6.5 (6-7); V= 58 (55-62).

Female Holotype: L= 2.04 mm.; a= 51; b= 6.6; c= 6; V= 59.

Description:

Female: Body tapering gradually anterior to slender part of esophagus and bent slightly posterior to vulva. Cuticle 2 μ thick on head and 4-6 μ on tail (thickest on tail tip); subcuticle faintly striated. Lateral hypodermal chords 1/7th corresponding body-width wide near middle. Amphids stirrup-shaped, about 3/4th lip-width wide. Sensillar pouches 25-30 μ from amphideal slit.

Lip region set off from body. Spear slender, 16-18 μ long; its extensions 10-12 μ long. Spear guiding ring inconspicuous, about 10-12 μ from anterior end. Basal bulb of esophagus 40-48 μ, slightly longer than the corresponding body-width or about 12% of the total esophageal length. Nerve ring 110-120 μ from anterior end of body. Cardia hemispheroid.

Vulva post-equatorial, longitudinal slit-like. Gonads amphidelphic. Uterus filled with sperms. Prerectum 230-250 μ

or about 8-10 anal body-widths long. Tail conoid, 31-36 μ or about one anal body-width long.

Male: Not found.

Type locality: Barwasamerpur, district Hamirpur

Type specimens: Holotype on slide P-201 L. magnus n. sp./1; paratypes on slides P-201 L. magnus n. sp./2-5.

Differential diagnosis: Leptonchus magnus n. sp., can be distinguished from all the other species in having longest body and longest spear.

GENUS PROLEPTONCHUS Lordello, 1955

Proleptonchus aestivus Lordello, 1955

Localities:

i) Jamalpur, district Aligarh
ii) Sakrar, district Jhansi
iii) Mohammadi, district Lakhimpur Kheri
iv) Nagal and Shyamapur, district Saharanpur
v) Azizpur and Lodhipur, district Shahjahanpur

FAMILY BELONENCHIDAE Thorne, 1964

GENUS BASIROTYLEPTUS Jairajpuri, 1964

Basirotyleptus basiri Jairajpuri, 1964

Localities:

i) Jamalpur, district Aligarh
ii) Patara, district Kanpur
iii) Mohammadi, district Lakhimpur Kheri
iv) Balakpur, district Pilibhit
v) Hasanpur, district Saharanpur

FAMILY DORYLAIMOIDIDAE Siddiqi, 1969

GENUS DORYLAIMOIDES Thorne and Swanger, 1936

Dorylaimoides arcuatus Siddiqi, 1963

Localities:

i) Pithuwala, district Dehradun
ii) Balakpur, district Pilibhit
iii) Gopalpur and Hasanpur, district Saharanpur

Dorylaimoides indicus Jairajpuri, 1965

Locality:

Shyamapur, district Saharanpur

Dorylaimoides arcuicaudatus Baqri and Jairajpuri, 1969

Localities:

i) Mussoorie, district Dehradun

ii) Accatair (Lukser), district Saharanpur

FAMILY TYLENCHOLAIMELLIDAE (Jairajpuri, 1964) Siddiqi, 1969

GENUS TYLENCHOLAIMELLUS N.A. Cobb in M.V. Cobb, 1915

Tylencholaimellus eskei Siddiqi and Khan, 1964

Localities:

i) Peenna Kanneuri and Rohana, district Muzaffarnagar

ii) Lalaurikhera, district Pilibhit

SUPERFAMILY BELONDIROIDEA Thorne, 1964

FAMILY DORYLAIMELLIDAE (Jairajpuri, 1964) Thorne, 1964

GENUS DORYLAIMELLUS Cobb, 1913

Dorylaimellus longicaudatus Jairajpuri, 1964

Localities:

i) Siar, district Ballia

ii) Barwe Sagar, district Jhansi

Dorylaimellus discocephalus Siddiqi, 1964

Locality:

Bankatra, district Shahjahanpur

Dorylaimellus indicus Siddiqi, 1964

Locality:

Majra, district Dehradun

FAMILY OXYDIRIDAE (Jairajpuri, 1964) Thorne, 1964

GENUS OXYDIRUS Thorne, 1939

Oxydirus gigus Siddiqi, 1964

Localities:

Waheedpur, Bankatra and Rosa, district Shahjahanpur

Oxydirus magnus Timm, 1964

Localities:

i) Sisr, district Ballia

ii) Rishikesh, district Dehradun

iii) Uldhan, district Meerut

iv) Baragaon, district Unnao

FAMILY SWANGERIDAE (Jairajpuri, 1964) Siddiqi, 1968

GENUS OUDSIELLA Jairajpuri, 1967

Oudsiella gracilis Jairajpuri, 1967

(Plate: XXV , Figs. E & F)

Dimensions:

Female (1): L= 1.27 mm.; a= 53; b= 6.9; c= 8;
V= 53.

Description:

Female: Body slender, slightly bent ventrally upon fixation. Lateral chords about 7 μ or 1/7th corresponding body-width wide near middle.

Lip region 7 μ wide, 4 μ high more or less rounded, continuous with the body. Amphids at the base of lip region; amphidial slit more than one-half the corresponding body-width wide. Spear attenuated with narrow lumen, about 9 μ long; spear extensions simple, 8 μ long. Nerve ring at 93 μ from anterior extremity. Basal expanded part of esophagus 73 μ or 34% of total esophageal length. Cardia 18 μ long, attached to the intestine with its posterior extremity.

Vulva transverse, slit-like. Vagina supported by cuticularized pieces. Gonads amphidelphic; ovaries reflexed. Prerectum 66 μ or 4 anal body-widths long. Rectum 17 μ or about 1 anal body-width long. Tail filiform, 190 μ or 11 anal body-widths long.

Locality:

Haldwani, district Nainital.

SUPERFAMILY DIPHTHEROPHOROIDEA Clark, 1961

FAMILY DIPHTHEROPHORIDAE(Micoletzky, 1922) Thorne, 1955

GENUS DIPHTHEROPHORA de Man, 1880

Diphtherophora parva Siddiqi, 1964

Locality:

Haldwani, district Nainital.

FAMILY TRICHODORIDAE (Thorne, 1935) Clark, 1961

GENUS TRICHODORUS Cobb, 1913

Trichodorus mirzai Siddiqi, 1960

Locality:

Mussoorie, district Dehradun

SUBORDER ALAIMINA (Micoletzky, 1922) Clark, 1961

SUPERFAMILY ALAIMOIDEA (Micoletzky, 1922) Goodey, 1963

FAMILY ALAIMIDAE Micoletzky, 1922

GENUS ALAIMUS de Man, 1880

Alaimus primitivus de Man, 1880

Localities:

i) Jamalpur, district Aligarh
ii) Izzatnagar, district Bareilly
iii) Barwe Sagar, district Jhansi
iv) Malihabad, district Lucknow
v) Waheedpur, district Shahjahanpur

GENUS AMPHIDELUS Thorne, 1939

Amphidelus dudichi Andrássy, 1957

Localities:

i) Waheedpur, district Shahjahanpur
ii) Gyanpur, district Varanasi

ORDER MONONCHIDA JAIRAJPURI, 1969

SUPERFAMILY BATHYODONTOIDEA (Clark, 1961) Jairajpuri, 1969

FAMILY MONONCHULIDAE (de Coninck, 1965) Jairajpuri, 1969

GENUS OIONCHUS Cobb, 1913

Oionchus obtusus Cobb, 1913
(Plate: XXV , Fig. C-I)

Dimensions:

Females (6): L= 1.01-1.08 mm.; a= 28-36; b= 3.6-4.0; c= 36-39; V= 59-61.

Description:

Female: Body almost straight upon fixation. Lateral chords not prominent.

Lip region slightly marked off. Stoma 15-16 μ x 9-10 μ. Mural tooth 10 μ from base of stoma. Extensions of stoma (telorhabdion) 14-15 μ long. Stoma with 2 transverse rows of denticles. Nerve ring 90-98 μ from anterior extremity.

Vulva depressed, transverse, slit-like. Vagina less than one-half the corresponding body-width long with 3-4 μ long cuticularized piece at its base. Ovary, prodelphic, reflexed. Post-uterine sac 6-8 μ, shorter than the body-width at vulva. Rectum about 1 anal body-width long. Tail obtusely rounded about 1 anal body-width long. Caudal glands and spinneret present. Spinneret sub-terminal and subdorsal with

well developed anchor apparatus.

Locality:

Gopalpur, district Saharanpur

Dionchus oryzae n. sp.

(Plate: XXV , Fig. J-P)

Dimensions:

Meerut population (type):

Female Paratypes (17): L= 1.25 mm. (1.18-1.45 mm.); a= 30 (27-36); b= 4.2 (3.8-4.8); c= 32 (30-33); V= 58 (50-63).

Female Holotype: L= 1.23 mm.; a= 28; b= 4.1; c= 33; V= 59.

Muzaffarnagar population:

Females (7): L= 1.07-1.42 mm.; a= 31-36; b= 3.8-4.6; c= 28-32; V= 54-63.

Description:

Female: Body almost straight upon fixation. Lateral chords inconspicuous.

Lip region slightly marked off. Cephalic papillae indistinct. Amphidial slits at the base of lips, 5-7 μ or less than one-half lip-width wide. Stoma 15 x 10 μ. Extensions of stoma 13-15 μ long. Mural tooth 14-15 μ long. Stoma bears

three transverse rows of denticles. Nerve ring 90-102 μ from anterior extremity.

Vulva transverse, slit-like. Ovary prodelphic reflexed. Vagina anteriorly directed, less than one-half the body-width at vulva. Tail 36-44 μ or 2 anal body-widths long. Caudal glands well developed. Anchor apparatus of spinneret very prominent, sub-terminal and subdorsal.

Male: Not found.

Type locality: Fields near Coca Cola Distillery, district Meerut.

Additional locality: Lakarsanda (Salempur), district Muzaffarnagar.

Type specimens: Holotype on slide P-140 O. oryzae n. sp./1; paratypes on slides P-140 O. oryzae n. sp./2-5.

Other females on slides P-132 O. oryzae/1-3.

Differential diagnosis: Oionchus oryzae n. sp., comes close to O. obtusus Cobb, 1913 from which it differs in having larger mural tooth; three rows of transverse denticles in stoma; absence of post-uterine sac; small cuticularized pieces at the base of vagina;longer tail with subterminal and subventral spinneret of caudal glands (mural tooth shorter than the length of buccal cavity; two rows of transverse denticles in stoma; post-uterine sac about 1 anal body-width long; larger cuticularized piece at the base of vagina; tail

less than 1 anal body-width long; caudal gland opening sub-terminal and subdorsal in O. obtusus).

SUPERFAMILY MONONCHOIDEA (Chitwood, 1937) Clark, 1961

FAMILY MONONCHIDAE Chitwood, 1937

GENUS MONONCHUS Bastian, 1865

Mononchus aquaticus Coetzee, 1968

Localities:

i) Pithuwala, district Dehradun
ii) Kasgunj, district Etah
iii) Bargarva, district Lakhimpur Kheri
iv) Bahadurpur, Ranipokhar and Haridwar, district Saharanpur
v) Rosa, district Shahjahanpur

GENUS PRIONCHULUS (Cobb, 1916) Wu and Hoeppli, 1929

Prionchulus muscorum (Dujardin, 1845)
Wu and Hoeppli, 1929

Localities:

i) Majra, district Dehradun
ii) Ranipokhar and Haridwar, district Saharanpur

FAMILY MYLONCHULIDAE Jairajpuri, 1969

SUBFAMILY MYLONCHULINAE Jairajpuri, 1969

GENUS MYLONCHULUS (Cobb, 1916) Altherr, 1953

Mylonchulus mulveyi Jairajpuri, 1970

Localities:

i) Mussoorie, district Dehradun

ii) Haldwani, district Nainital

Mylonchulus lacustris (N.A. Cobb in M.V. Cobb, 1915) Andrássy, 1958

Localities:

i) Izzatnagar, district Bareilly

ii) Pathria and Luksar, district Saharanpur

iii) Rose, district Shahjahanpur

FAMILY ANATONCHIDAE Jairajpuri, 1969

GENUS MICONCHUS Andrassy, 1959

Miconchus indicus n. sp.

(Plate: XXVII, Fig. A-F)

Dimensions:

Male Paratypes (5): L= 1.46-2.05 mm.; a= 26-34; b= 3.9-4.2; c= 18-20; T= 30-34.

Female Holotype: L= 1.94 mm.; a= 24; b= 3.7; c= 19; V= 79.

Description:

Female: Body ventrally arcuate upon fixation. Cuticle smooth.

Lip region set off from the body, 40 µ wide, 17 µ high. Amphid small cup-like situated at the base of lip region 16-17 µ from anterior end of the body. Buccal cavity 43 x 30 µ. Apex of dorsal tooth 16 µ from base of stome. Dorsal and vertical subventral walls each bear a tooth of equal size. Esophago-intestinal junction tuberculate.

Vulva a depressed transverse slit. Vagina less than one-half the body-width at vulva. Vulval slit guarded by small cuticularized pieces. Gonads amphidelphic with reflexed ovaries. Oocytes arranged in multiple rows. Proximal part of oviduct swells to form a spermetheca-like structure. Oviduct-uterus

junction guarded by strong sphinctors. There are 7 pre-vulval body pores and a single post-vulval. Tail elongate-conoid with rounded tip; 131 µ or about 3 anal body-widths long. Caudal glands present; spinneret terminal.

Male: Buccal cavity 41-52 µ x 28-30 µ, dorsal tooth 16-17 µ from base of stoma. Spicules 52-67 µ medially. Lateral accessory piece 15-17 µ long. Supplements 17-21 in number.

Type locality: Paddy fields in district Chittaurgarh, Rajasthan.

Type specimens: Holotype on slide M. indicus n. sp./1; paratypes on slides M. indicus n. sp./2-3.

Differential diagnosis: Miconchus indicus n. sp., comes close to M. exilis (Cobb, 1917) Andrassy, 1968 and M. kansasensis Mulvey and Dickerson, 1970. From both the species it differs in having well developed caudal glands and spinneret. From M. exilis it again differs in having a longer tail (c= 55 in M. exilis). From M. kansasensis it further differs in having posteriorly located vulva; dorsal tooth at the base of buccal cavity; and flatly rounded tail tip (vulva 70-72%; dorsal tooth near middle of buccal cavity; and tail tip pointed in M. Kansasensis).

FAMILY IOTONCHIDAE Jairajpuri, 1969

GENUS HADRONCHUS Mulvey and Jensen, 1967

Hadronchus shakili Jairajpuri, 1969

Locality:

Baragaon, district Lakhimpur Kheri

Part III.

Distribution of Nematodes of Paddy in Uttar Pradesh

DISTRIBUTION OF NEMATODES OF PADDY IN UTTAR PRADESH

The knowledge of nematodes of paddy is inadequate. A systematic survey of paddy fields so as to obtain a complete record of plant-parasitic as well as soil-inhabiting nematodes was not done so far. The present survey work was carried out during 1968-70. About 200 samples were collected from 23 major paddy growing districts of Uttar Pradesh. These samples upon analysis yielded 63 genera belonging to 35 families and 14 superfamilies of order Tylenchida, Dorylaimida and Mononchida. In all 110 species were identified.

The following is the list of genera arranged systematically.

ORDER TYLENCHIDA THORNE, 1949

SUBORDER TYLENCHINA Geraert, 1966

SUPERFAMILY TYLENCHOIDEA (Orley, 1880) Chitwood and Chitwood, 1937

FAMILY TYLENCHIDAE Orley, 1880

1. Tylenchus Bastian, 1865
2. Ditylenchus Filipjev, 1936
3. Pseudhalenchus Tarjan, 1958

4. Psilenchus de Man, 1921
5. Basiria Siddiqi, 1959
6. Clavilenchus (Jairajpuri, 1966) Thorne and Malek, 1968

FAMILY TYLENCHORHYNCHIDAE (Eliava, 1964) Golden, 1971

7. Tylenchorhynchus Cobb, 1913

FAMILY BELONOLAIMIDAE (Whitehead, 1959) Siddiqi, 1970

8. Trichotylenchus Whitehead, 1959

FAMILY HOPLOLAIMIDAE (Filipjev, 1934) Wieser, 1953

9. Hoplolaimus Daday, 1905
10. Rotylenchus Filipjev, 1936
11. Helicotylenchus Steiner, 1945
12. Rotylenchulus Linford and Oliveira, 1940

FAMILY PRATYLENCHIDAE (Thorne, 1949) Siddiqi, 1963

13. Pratylenchus Filipjev, 1936
14. Hirschmanniella Luc and Goodey, 1963

SUPERFAMILY HETERODEROIDEA (Filipjev, 1934) Golden, 1971

FAMILY HETERODERIDAE (Filipjev, 1934) Skarbilovich, 1947

15. Meloidogyne Goeldi, 1887

SUPERFAMILY CRICONEMATOIDEA (Taylor, 1936) Geraert, 1966

FAMILY CRICONEMATIDAE (Taylor, 1936) Thorne, 1949

16. Hemicriconemoides Chitwood and Birchfield, 1957

FAMILY PARATYLENCHIDAE (Thorne, 1949) Raski, 1962

17. Paratylenchus Micoletzky, 1922

SUPERFAMILY NEOTYLENCHOIDEA (Thorne, 1941) Jairajpuri and Siddiqi, 1969

FAMILY NEOTYLENCHIDAE (Thorne, 1941) Thorne, 1949

18. Hexatylus T. Goodey, 1926
19. Paladenus Thorne, 1941

FAMILY PAURODONTIDAE (Thorne, 1941) Massey, 1967

20. Paurodontus Thorne, 1941

FAMILY NOTHOTYLENCHIDAE (Thorne, 1941) Jairajpuri and Siddiqi, 1969

21. Nothotylenchus Thorne, 1941
22. Sakia S.H. Khan, 1964
23. Boleodorus Thorne, 1941

FAMILY ECPHYADOPHORIDAE Skarbilovich, 1959

24. Ecphyadophora de Man, 1921

SUBORDER APHELENCHINA (Thorne, 1949) Geraert, 1966

SUPERFAMILY APHELENCHOIDEA (Fuchs, 1937) Thorne, 1949

FAMILY APHELENCHIDAE (Fuchs, 1937) Steiner, 1949

25. Aphelenchus Bastian, 1865

FAMILY APHELENCHOIDIDAE (Skarbilovich, 1947) Paramonov, 1953

26. Aphelenchoides Fischer, 1894
27. Seinura Fuchs, 1931

ORDER DORYLAIMIDA PEARSE, 1942

SUBORDER DORYLAIMINA (Chitwood, 1933) Pearse, 1936

SUPERFAMILY DORYLAIMOIDEA (de Man, 1876) Thorne, 1934

FAMILY DORYLAIMIDAE de Man, 1876

28. Eudorylaimus Andrássy, 1959
29. Mesodorylaimus Andrássy, 1959
30. Labronema Thorne, 1939
31. Thornenema Andrássy, 1959
32. Pungentus Thorne and Swanger, 1936
33. Discolaimus Cobb, 1913
34. Discolaimium Thorne, 1939
35. Longidorella Thorne, 1939

FAMILY APORCELAIMIDAE Heyns, 1965

36. Aporcelaimus Thorne and Swanger, 1936
37. Aporcelaimellus Heyns, 1965
38. Sectonema Thorne, 1930

FAMILY LONGIDORIDAE (Thorne, 1935) Meyl, 1961

39. Longidorus (Micoletzky, 1922) Filipjev, 1934
40. Xiphinema Cobb, 1913
41. Paralongidorus Siddiqi, Hooper and E. Khan, 1963

FAMILY TYLENCHOLAIMIDAE (Filipjev, 1934) Siddiqi, 1969

42. Tylencholaimus de Man, 1876

SUPERFAMILY NYGOLAIMOIDEA (Thorne, 1935) de Coninck, 1965

FAMILY NYGOLAIMIDAE (Thorne, 1935) Meyl, 1960

43. Nygolaimus Cobb, 1913

SUPERFAMILY ACTINOLAIMOIDEA Thorne, 1967

FAMILY PARACTINOLAIMIDAE Thorne, 1967

44. Paractinolaimus Meyl, 1957

FAMILY NEOACTINOLAIMIDAE Thorne, 1967

45. Neoactinolaimus Thorne, 1967

SUPERFAMILY LEPTONCHOIDEA (Thorne, 1935) V.R. Ferris, 1971

FAMILY LEPTONCHIDAE Thorne, 1935

46. Leptonchus Cobb, 1920

47. Proleptonchus Lordello, 1956

FAMILY BELONENCHIDAE Thorne, 1964

48. Basirotyleptus Jairajpuri, 1964

FAMILY DORYLAIMOIDIDAE Siddiqi, 1969

49. Dorylaimoides Thorne and Swanger, 1936

FAMILY TYLENCHOLAIMELLIDAE (Jairajpuri, 1964) Siddiqi, 1969

50. Tylencholaimellus N.A. Cobb in M.V. Cobb, 1915

SUPERFAMILY BELONDIROIDEA Thorne, 1964

FAMILY DORYLAIMELLIDAE (Jairajpuri, 1964) Thorne, 1964

51. Dorylaimellus Cobb, 1913

FAMILY OXYDIRIDAE (Jairajpuri, 1964) Thorne, 1964

52. Oxydirus Thorne, 1939

FAMILY SWANGERIDAE (Jairajpuri, 1964) Siddiqi, 1968

53. Cudsiella Jairajpuri, 1967

SUPERFAMILY DIPHTHEROPHOROIDEA Clark, 1961

FAMILY DIPHTHEROPHORIDAE (Micoletzky, 1922) Thorne, 1955

54. Diphtherophora de Man, 1880

FAMILY TRICHODORIDAE (Thorne, 1935) Clark, 1961

55. Trichodorus Cobb, 1913

SUBORDER ALAIMINA (Micoletzky, 1922) Clark, 1961

SUPERFAMILY ALAIMOIDEA (Micoletzky, 1922) Goodey, 1963

FAMILY ALAIMIDAE Micoletzky, 1922

56. Alaimus de Man, 1880

57. Amphidelus Thorne, 1939

ORDER MONONCHIDA JAIRAJPURI, 1969

SUPERFAMILY BATHYODONTOIDEA (Clark, 1961) Jairajpuri, 1969

FAMILY MONONCHULIDAE (de Coninck, 1965) Jairajpuri, 1969

58. Dionchus Cobb, 1913

SUPERFAMILY MONONCHOIDEA (Chitwood, 1937) Clark, 1961

FAMILY MONONCHIDAE Chitwood, 1937

59. Mononchus Bastian, 1865

60. Prionchulus (Cobb, 1916) Wu & Hoeppli, 1929

FAMILY MYLONCHULIDAE Jairajpuri, 1969

61. Mylonchulus (Cobb, 1916) Altherr, 1953

62. Sporonchulus (Cobb, 1917) Pennak, 1953

FAMILY IOTONCHIDAE Jairajpuri, 1969

63. Hadronchus Mulvey and Jensen, 1967

DISTRICTS SURVEYED

1.	Aligarh	2.	Azamgarh
3.	Ballia	4.	Bareilly
5.	Bijnor	6.	Dehradun
7.	Etah	8.	Ghazipur
9.	Hamirpur	10.	Hardoi
11.	Jhansi	12.	Kanpur
13.	Lakhimpur Kheri	14.	Lucknow
15.	Meerut	16.	Muzaffarnagar
17.	Nainital	18.	Pilibhit
19.	Saharanpur	20.	Shahjahanpur
21.	Sitapur	22.	Unnao

23. Varanasi

The numbers under the column District(s) on page 132-136 refer to the above.

NEMATODE SPECIES	DISTRICT(S)
Tylenchus striatus	9,11,23
T. parvus	1,6,18,20
T. arcuatus	1,6,11,13,20
T. ritai	1,4-6,10,14-21
Ditylenchus triformis	6
D. mirus	1,6,7,15,17
D. nanus	1,4,5,15,17,20
D. clavicaudatus	1
Pseudhalenchus anchilisposomus	18
Basiria graminophilla	11
Psilenchus hilarulus	1,6
P. neoformis	1,6,19
P. minor	6
Clavilenchus tumidus	14
C. ritteri	6,16
Tylenchorhynchus brevidens	15,19
T. capitatus	17
T. mashhoodi	1-7,10,13,14-22
T. divittatus	11,15,19
T. goffarti	23
T. delhiensis	20
Trichotylenchus indicus	20
T. serolatus	11

NEMATODE SPECIES	DISTRICT(S)
Hoplolaimus indicus	1,4,6,10,11,13,15-18 20,22,23
H. columbus	18
H. neoformis	17
Rotylenchus buxophilus	6
Helicotylenchus indicus	4,6,20
H. retusus	6,9,11,20,23
H. digitatus	1,3,4,18,20
H. jhansiensis	11
H. implicatus	17
H. acuticaudatus	18
H. novus	18
Pratylenchus vulnus	18
P. thornei	15,19
P. gaiseri	18
Hirschmanniella oryzae	1-4,6-8,10,12,13,15-23
H. gracilis	5,18
H. tissi	3,11,14,18
H. indica	6,11,15
Hemicriconemoides squamosus	6,17
Paratylenchus aculentus	21
P. nainiamus	20
P. oryzae	20
Hexatylus viviparus	4,6

NEMATODE SPECIES	DISTRICT(S)
Paurodontus gracilis	18
Deladenus durus	3
Nothotylenchus acris	5,6
N. drymoecolus	14
N. innuptus	1,20
N. basiri	4,20
N. acutus	3,6,20
N. acuticaudatus	15
Boleodorus thylactus	4,6
B. impar	19
Sakia indica	16,19
S. oryzae	17
Ecphyadophora tenuissima	1,19
Aphelenchus avenae	1,3,15-17,19,20
A. mashhoodi	15
Aphelenchoides bicaudatus	4,15,16,20
A. aligarhiensis	1,3-5,20
A. delhiensis	6,19
Seinura basiri	6
S. indica	13
Thornenema mauritianum	16
Pungentus angulatus	20
Discolaimus similis	11,20
D. brevis	1,3

NEMATODE SPECIES	DISTRICT(S)
Discolaimium bulbiferum	4,16
D. monhystera	1
D. arcuatum	22
D. upum	6,19
D. indicum	20
Longidorella parva	5,16
Aporcelaimellus obtusicaudatus	1
Sectonema procta	20
Longidorus brevicaudatus	1,19,21
Xiphinema americanum	20,21
Paralongidorus citri	15
P. parvus	13
Tylencholaimus obscurus	4,6,15,19
Nygolaimus aquaticus	1,3,6,15,18-20
Neoactinolaimus agilis	1,4,6,19,20,23
Leptonchus granulosus	1,6,11,14,15,19
L. magnus	9
Proleptonchus aestivus	1,11,13,19,20
Basirotyleptus basiri	1,12,13,18,19
Dorylaimoides arcuatus	6,18,19
D. indicus	19
D. arcuicaudatus	6,19
Tylencholaimellus eskei	16,18

NEMATODE SPECIES	DISTRICT(S)
Dorylaimellus indicus	6
D. longicaudatus	3,11
D. discocephalus	20
Oxydirus magnus	3,6,15,22
O. gigas	20
Cudsiella gracilis	17
Diphtherophora parva	17
Trichodorus mirzai	6
Alaimus primitivus	1,4,11,14,20
Amphidelus dudichi	20,23
Dionchus obtusus	3,4,16,19
D. oryzae	16
Mononchus aquaticus	6,7,13,19,20
Prionchulus muscorum	6,19
Mylonchulus mulveyi	6,17
M. lacustris	4,19,20
Hadronchus shakili	13

QUANTITATIVE STUDY OF NEMATODES ASSOCIATED WITH PADDY IN UTTAR PRADESH

A detailed survey was carried out to find out the frequency of occurrence of different nematode genera associated with paddy and their inter-relationship. For this purpose about 200 soil and root (where available) samples from the following 20 districts were studied. These districts include several major paddy growing areas of Uttar Pradesh: Aligarh, Azamgarh, Ballia, Bareilly, Dehradun, Etah, Ghazipur, Hamirpur, Hardoi, Kanpur, Lakhimpur Kheri, Lucknow, Meerut, Muzaffarnagar, Nainital, Pilibhit, Saharenpur, Shahjahanpur, Sitapur and Unnao.

METHODOLOGY:

Sampling and Isolation: Same as described in 'Materials and Methods' except that only 100 ml. of soil and 10 gms. of roots were processed for this study from the bulk samples.

Nematode Counting: The suspensions of nematodes in clear water obtained from 100 ml. of soil and 10 gms. of roots were taken in a beaker and made to 100 ml. by adding required amount of water. The suspensions were made homogenous by passing air with the help of an aerator, bubler

or pipette. 10 ml. from each suspension was taken out by a pipette into a 'syracuse counting dish' for nematode counting. Three countings were found sufficient to workout the number of nematodes present in 100 ml. of soil and 10 gms. roots respectively.

NEMATODES GROUPING:

The nematodes studied were grouped in the following four categories based on their feeding habits: Plant parasites (including suspected plant parasites), Other Tylenchida and Dorylaimida, Saprophagous nematodes and Predaceous nematodes.

1. Plant Parasites: This group includes both endo- and ectoparasitic forms and also the suspected plant-parasitic forms of the following families: Tylenchidae, Tylenchorhynchidae, Hoplolaimidae, Pratylenchidae, Criconematidae, Paratylenchidae, Aphelenchidae, Aphelenchoididae and Longidoridae

2. Other Tylenchida and Dorylaimida: This group includes nematode genera of the order Tylenchida and Dorylaimida which are either free-living or non-parasitic in nature. Some of these may later prove as palnt-parasitic forms. They belong to the following families: Neotylenchidae, Nothotylenchidae, Dorylaimidae, Neoactinolaimidae, Leptonchidae, Belonenchidae Dorylaimoididae, and Alaimidae.

3. Saprophagous Nematodes: The non-parasitic Tylenchida and Dorylaimida have been grouped separately, while the saprophagous, free-living and predaceous nematodes have been delt under the head 'Other forms'.

4. Predaceous Nematodes: This group includes nematode genera of the following families: Mononchulidae, Mononchidae, Mylonchulidae and Iotonchidae. These nematodes include several predaceous forms which feed upon plant-parasitic nematodes. They have been dealt under the head 'Mononchida'.

ALIGARH

Nematodes	Soil per 100 ml.	Roots per 10 gms.
Hirschmanniella	60 - 300	20 - 150
Tylenchorhynchus	20 - 500	10 - 250
Hoplolaimus	30 - 150	10 - 30
Helicotylenchus	30 - 120	10 - 60
Pratylenchus	50 - 350	30 - 200
Aphelenchoides	50 - 250	20 - 100
Aphelenchus	50 - 280	30 - 150
Hemicriconemoides	10 - 40	Nil
Tylenchus	30 - 150	20 - 80
Psilenchus	40 - 130	20 - 100
Other Tylenchida	20 - 120	10 - 80
Other Dorylaimida	240 - 1450	150 - 650
Other Forms	30 - 300	20 - 200

AZAMGARH

Hirschmanniella	20 - 220	10 - 160
Tylenchorhynchus	40 - 120	30 - 110
Hoplolaimus	30 - 100	20 - 90
Helicotylenchus	20 - 150	10 - 80
Aphelenchoides	40 - 170	20 - 80
Tylenchus	20 - 350	20 - 250
Other Tylenchida	30 - 280	20 - 160
Other Dorylaimida	1110 - 1450	120 - 680
Other Forms	60 - 700	30 - 300

BALLIA

Nematodes	Soil per 100 ml.	Roots per 10 gms.
Hirschmanniella	70 - 360	30 - 150
Tylenchorhynchus	60 - 680	20 - 300
Hoplolaimus	80 - 230	10 - 50
Helicotylenchus	30 - 150	20 - 120
Aphelenchoides	60 - 180	30 - 100
Tylenchus	50 - 230	20 - 180
Aphelenchus	60 - 260	30 - 80
Other Tylenchida	30 - 150	20 - 80
Other Dorylaimida	740 - 1250	150 - 450
Other Forms	50 - 250	Nil

BAREILLY

Hirschmanniella	30 - 70	20 - 60
Tylenchorhynchus	30 - 150	20 - 90
Hoplolaimus	50 - 140	30 - 70
Helicotylenchus	30 - 80	20 - 60
Aphelenchoides	20 - 60	10 - 30
Tylenchus	100 - 170	50 - 110
Aphelenchus	20 - 30	10 - 20
Other Tylenchida	20 - 210	10 - 130
Other Dorylaimida	280 - 1610	190 - 640
Other Forms	30 - 130	10 - 60

DEHRADUN

Nematodes	Soil per 100 ml.	Roots per 10 gms.
Hirschmanniella	40 - 230	20 - 110
Tylenchorhynchus	30 - 290	10 - 170
Helicotylenchus	20 - 100	10 - 20
Aphelenchoides	40 - 110	10 - 60
Tylenchus	10 - 260	10 - 180
Ditylenchus	30 - 50	10 - 20
Aphelenchus	20 - 40	10 - 30
Psilenchus	40 - 230	30 - 190
Hemicriconemoides	10 - 40	Nil
Other Tylenchida	30 - 240	20 - 50
Other Dorylaimida	100 - 1320	60 - 890
Other Forms	20 - 340	10 - 260

ETAH

Hirschmanniella	70 - 330	20 - 170
Tylenchorhynchus	80 - 240	30 - 130
Hoplolaimus	40 - 160	20 - 140
Helicotylenchus	20 - 80	10 - 60
Aphelenchoides	30 - 70	20 - 150
Tylenchus	30 - 160	10 - 150
Other Tylenchida	40 - 130	20 - 120
Other Dorylaimida	350 - 680	190 - 690
Monochida	50 - 180	-
Other Forms	60 - 300	30 - 250

GHAZIPUR

Nematodes	Soil per 100 ml.	Roots per 10 gms.
Hirschmanniella	60 - 220	Nil
Tylenchorhynchus	110 - 430	...
Hoplolaimus	90 - 200	...
Helicotylenchus	70 - 170	...
Aphelenchoides	60 - 130	...
Tylenchus	70 - 160	...
Aphelenchus	40 - 150	...
Other Tylenchida	60 - 190	...
Other Dorylaimida	460 - 870	...
Other Forms	30 - 300	...

HAMIRPUR

Tylenchorhynchus	60 - 430	...
Hoplolaimus	50 - 250	...
Helicotylenchus	60 - 330	...
Aphelenchoides	20 - 70	...
Tylenchus	50 - 280	...
Other Tylenchida	20 - 90	...
Other Dorylaimida	790 - 1240	...
Other Forms	30 - 450	...

HARDOI

Nematodes	Soil per 100 ml.	Roots per 10 gms.
Hirschmanniella	90 - 160	...
Tylenchorhynchus	90 - 540	...
Hoplolaimus	50 - 80	...
Tylenchus	20 - 100	...
Other Tylenchida	20 - 160	...
Other Dorylaimida	340 - 1210	...
Other Forms	30 - 90	...

KANPUR

Hirschmanniella	90 - 240	...
Tylenchorhynchus	270 - 1170	...
Hoplolaimus	200 - 300	...
Helicotylenchus	30 - 100	...
Tylenchus	70 - 260	...
Ditylenchus	50 - 230	...
Aphelenchus	150 - 200	...
Other Tylenchida	20 - 270	...
Other Dorylaimida	510 - 1040	...
Other Forms	130 - 1290	...

LAKHIMPUR KHERI

Nematodes	Soil per 100 ml.	Roots per 10 gms.
Hirschmanniella	30 - 190	Nil
Tylenchorhynchus	210 - 870	...
Hoplolaimus	20 - 70	...
Helicotylenchus	210 - 300	...
Pratylenchus	20 - 70	...
Tylenchus	30 - 190	...
Other Tylenchida	30 - 120	...
Other Dorylaimida	530 - 1140	...
Mononchida	10 - 30	...
Other Forms	140 - 300	...

LUCKNOW

Hirschmanniella	100 - 350	60 - 150
Tylenchorhynchus	80 - 410	40 - 170
Hoplolaimus	50 - 90	20 - 50
Helicotylenchus	30 - 140	20 - 160
Paratylenchus	20 - 60	10 - 40
Aphelenchus	30 - 110	20 - 50
Other Tylenchida	30 - 110	20 - 50
Other Dorylaimida	430 - 1170	210 - 850
Other Forms	70 - 130	30 - 160

MEERUT

Nematodes	Soil per 100 ml.	Roots per 10 gms.
Hirschmanniella	40 - 240	30 - 150
Tylenchorhynchus	40 - 700	20 - 450
Hoplolaimus	30 - 110	10 - 100
Helicotylenchus	30 - 200	20 - 70
Pratylenchus	40 - 300	30 - 170
Tylenchus	40 - 100	30 - 170
Ditylenchus	20 - 40	20 - 50
Psilenchus	30 - 40	20 - 70
Other Tylenchida	30 - 110	20 - 90
Other Dorylaimida	1160 - 2500	430 - 1700
Other Forms	60 - 350	20 - 300

MUZAFFARNAGAR

Hirschmanniella	50 - 170	30 - 120
Tylenchorhynchus	60 - 130	30 - 50
Hoplolaimus	40 - 160	20 - 80
Helicotylenchus	90 - 390	30 - 160
Aphelenchoides	30 - 180	20 - 160
Tylenchus	20 - 250	20 - 150
Aphelenchus	30 - 350	20 - 140
Psilenchus	30 - 100	20 - 30
Other Tylenchida	20 - 130	10 - 110
Other Dorylaimida	230 - 1870	150 - 740
Other Forms	30 - 2200	20 - 1300

NAINITAL

Nematodes	Soil per 100 ml.	Roots per 10 gms.
Hirschmanniella	60 - 130	50 - 90
Tylenchorhynchus	30 - 150	20 - 160
Helicotylenchus	170 - 230	110 - 200
Tylenchus	80 - 230	50 - 170
Ditylenchus	20 - 50	10 - 30
Aphelenchus	20 - 50	10 - 30
Hemicriconemoides	20 - 30	Nil
Other Tylenchida	20 - 100	10 - 70
Other Dorylaimida	320 - 1970	280 - 1310
Other Forms	30 - 130	30 - 150

PILIBHIT

Hirschmanniella	100 - 180	50 - 100
Tylenchorhynchus	30 - 300	20 - 210
Hoplolaimus	20 - 50	20 - 40
Helicotylenchus	20 - 60	20 - 50
Tylenchus	20 - 60	20 - 50
Other Tylenchida	20 - 50	20 - 60
Other Dorylaimida	190 - 1450	170 - 1370
Other Forms	30 - 60	20 - 30

SAHARANPUR

Nematodes	Soil per 100 ml.	Roots per 10 gms.
Hirschmanniella	60 - 300	70 - 250
Tylenchorhynchus	60 - 370	50 - 130
Hoplolaimus	20 - 50	10 - 30
Helicotylenchus	30 - 790	20 - 340
Aphelenchoides	60 - 130	50 - 110
Tylenchus	50 - 560	20 - 170
Aphelenchus	20 - 90	20 - 70
Psilenchus	50 - 430	30 - 250
Other Tylenchida	60 - 320	50 - 190
Other Dorylaimida	200 - 2700	160 - 1310
Other Forms	60 - 810	30 - 340

SHAHJAHANPUR

Hirschmanniella	40 - 190	30 - 170
Tylenchorhynchus	50 - 430	40 - 330
Hoplolaimus	20 - 80	10 - 60
Helicotylenchus	30 - 100	20 - 70
Aphelenchoides	30 - 80	10 - 70
Aphelenchus	60 - 180	20 - 130
Tylenchus	30 - 450	20 - 300
Psilenchus	30 - 200	20 - 170
Other Tylenchida	30 - 90	20 - 110
Other Dorylaimida	170 - 930	210 - 610
Other Forms	30 - 400	30 - 330

SITAPUR

Nematodes	Soil per 100 ml.	Roots per 10 gms.
Hirschmanniella	80 - 250	70 - 210
Tylenchorhynchus	70 - 250	50 - 100
Hoplolaimus	20 - 70	20 - 50
Helicotylenchus	20 - 50	30 - 40
Aphelenchus	50 - 80	30 - 60
Tylenchus	30 - 110	20 - 100
Xiphinema	20 - 40	10 - 30
Longidorus	10 - 200	Nil
Other Tylenchida	30 - 150	20 - 130
Other Dorylaimida	210 - 870	120 - 510
Other Forms	70 - 470	30 - 130

UNNAO

Hirschmanniella	80 - 430	70 - 210
Tylenchorhynchus	70 - 270	50 - 250
Hoplolaimus	10 - 70	10 - 50
Helicotylenchus	10 - 30	10 - 20
Tylenchus	40 - 80	30 - 70
Aphelenchus	30 - 50	20 - 40
Other Tylenchida	30 - 80	30 - 70
Other Dorylaimida	360 - 930	210 - 670
Monenchida	10 - 20	-
Other Forms	90 - 310	70 - 270

DISCUSSION:

The results of quantitative studies show that the relative frequency of occurrence of plant-parasitic nematodes in paddy fields is as follows: Hirschmanniella 95%, Tylenchorhynchus 75%, Helicotylenchus 60%, Aphelenchus 60%, Aphelenchoides 40% and Hoplolaimus 30%. The infection of Hirschmanniella is very common in Uttar Pradesh. In fields where paddy is grown year after year the population of Hirschmanniella is very high. The species, Hirschmanniella oryzae occurs most commonly around paddy in India. The genera Pratylenchus and Ditylenchus are rare, perhaps they do not like the aquatic environment. The species of Psilenchus and Tylenchus were found frequently around paddy roots particularly in the Western districts of Uttar Pradesh. Species of Hemicriconemoides, Ecphyadophora, Xiphinema and Longidorus were found but are rare. The species Hygrolaimus aquaticus of the order Dorylaimida and Mononchus aquaticus of Mononchida are the two widely distributed species around paddy.

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+For appendix to references please see page 170.

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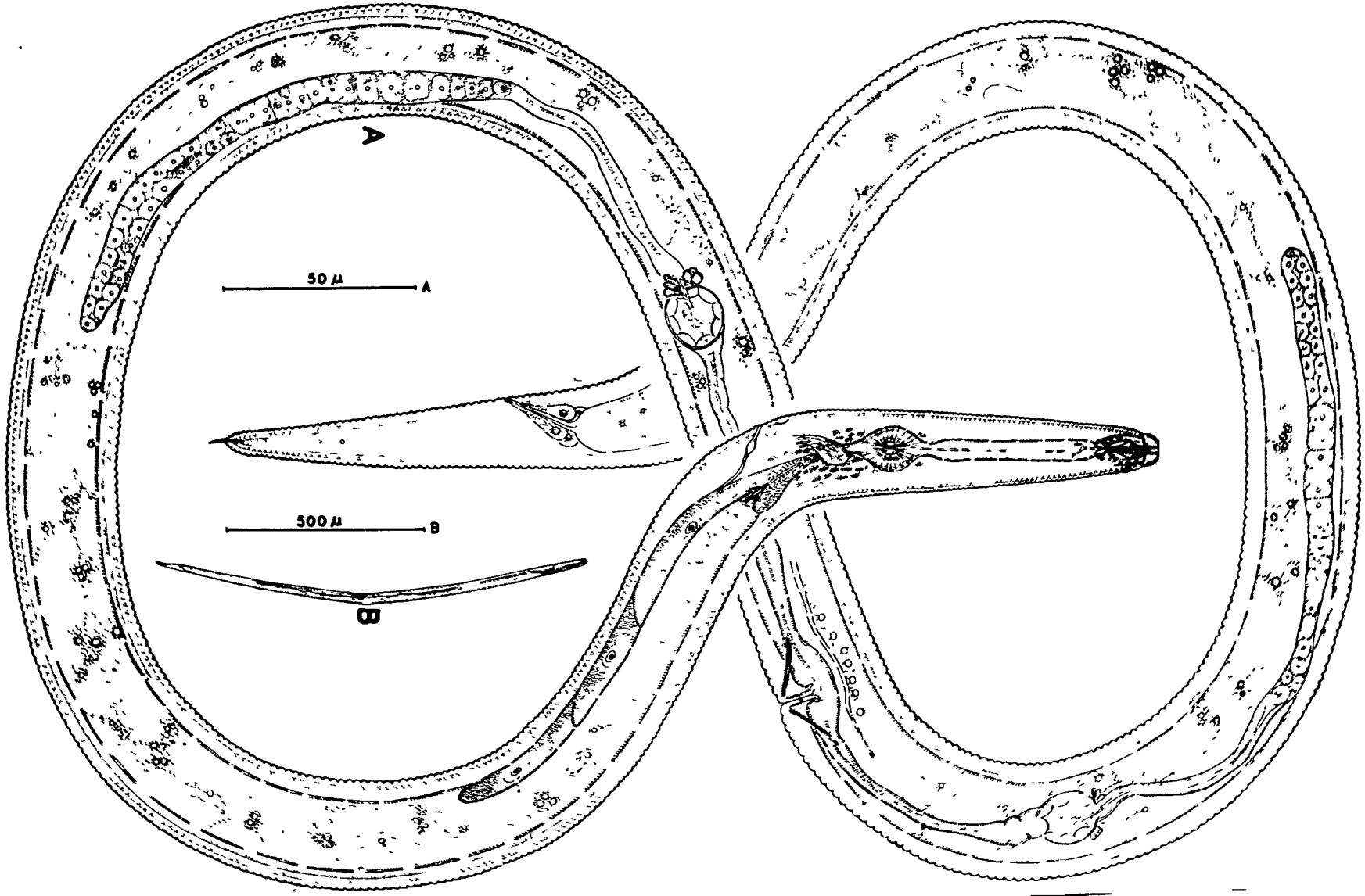
Plates I–XXVI.

P L A T E: I.

Figs. A, B *Hirschmanniella oryzae* (Soltwedel, 1889) Luc and Goodey, 1963.

A. Entire female

B. Actual shape of female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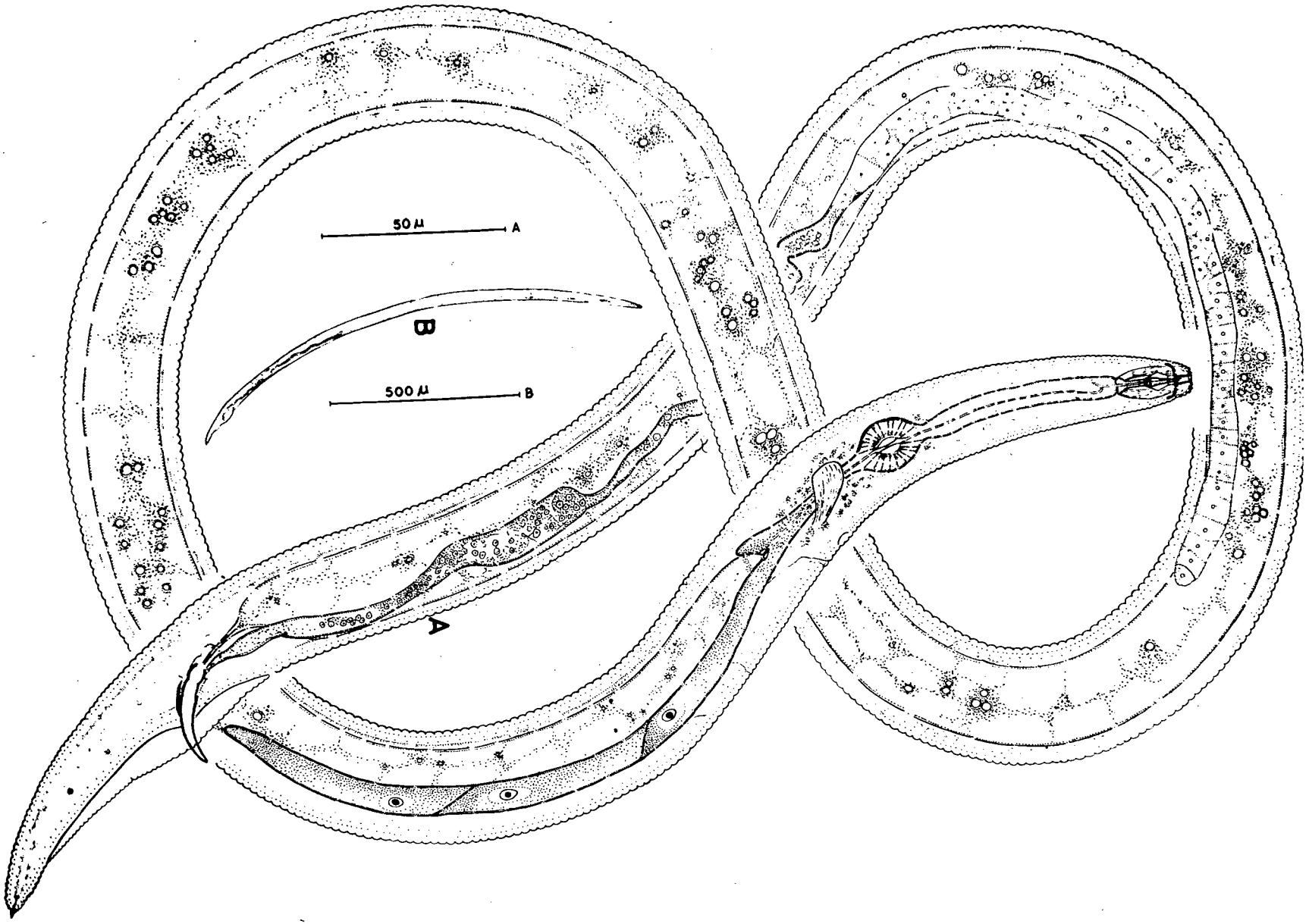
P L A T E: II.

Figs. A, B *Hirschmanniella oryzae* (Soltwedel, 1889) Luc and Goodey, 1963.

A. Entire male

B. Actual shape of male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P L A T E: III.

Figs. A-K CUTICULAR MODIFICATIONS

A. Head end of female showing Amphids and Cephalids.

B. Anterior region of female showing origin of lateral fields.

C. Anterior region of female showing anastomosis.

D. Lateral fields with incomplete areolation in the pre-vulval region.

E. Lateral fields with complete areolation in the post-vulval region.

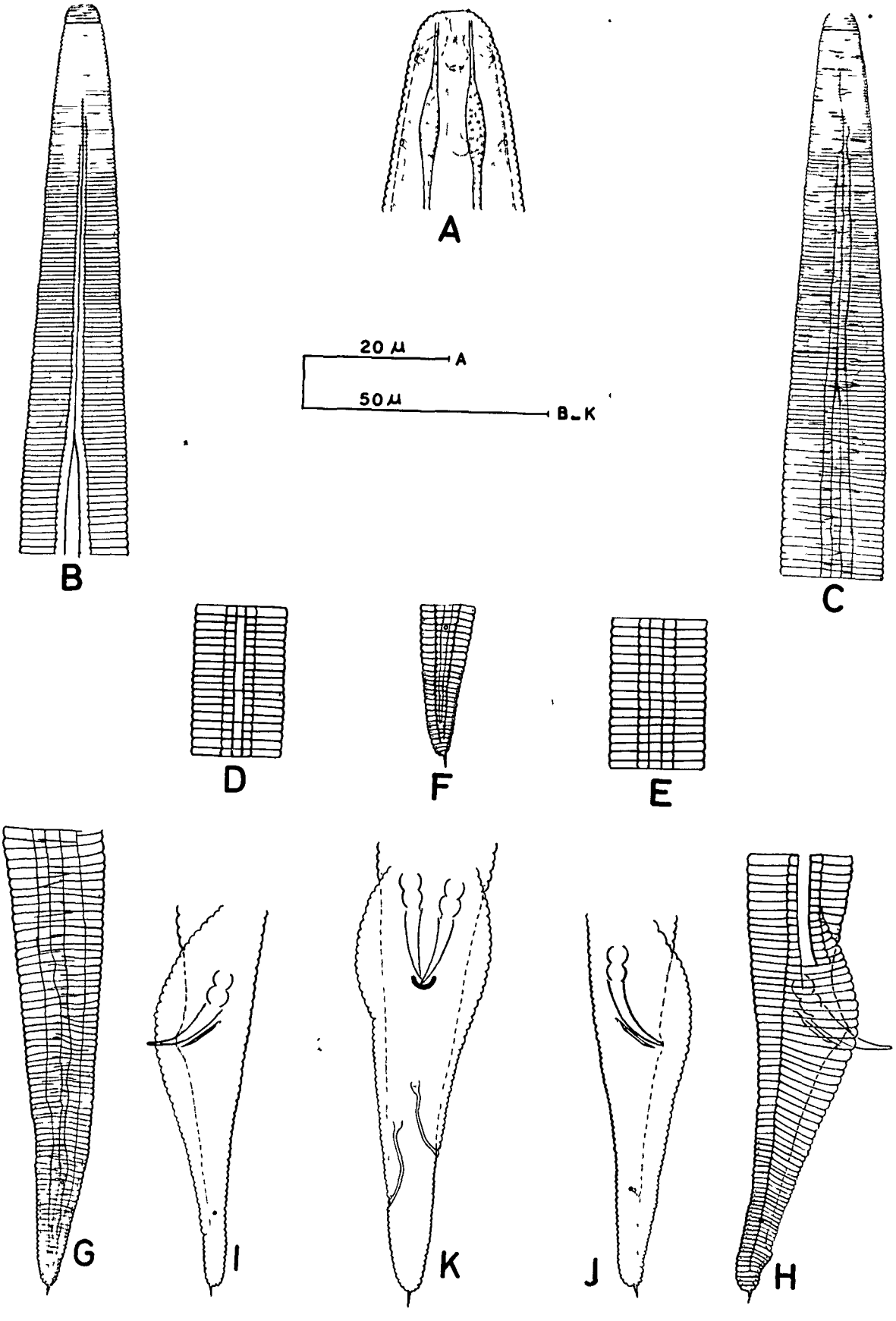
F. Lateral fields with complete areolation in tail region.

G. Lateral fields on tail showing anastomosis.

H. Lateral fields on male tail.

I & J. Male tails showing origin and termination of caudal alae.

K. Male tail in dorso-ventral position.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P L A T E: IV.

Figs. A-N TAIL SHAPES

A-D. Leaf shaped tails of females.

E & F. Tail tips with additional striae

G & H. Posterior halves of male tails.

I. Female tail tip dorso-ventral.

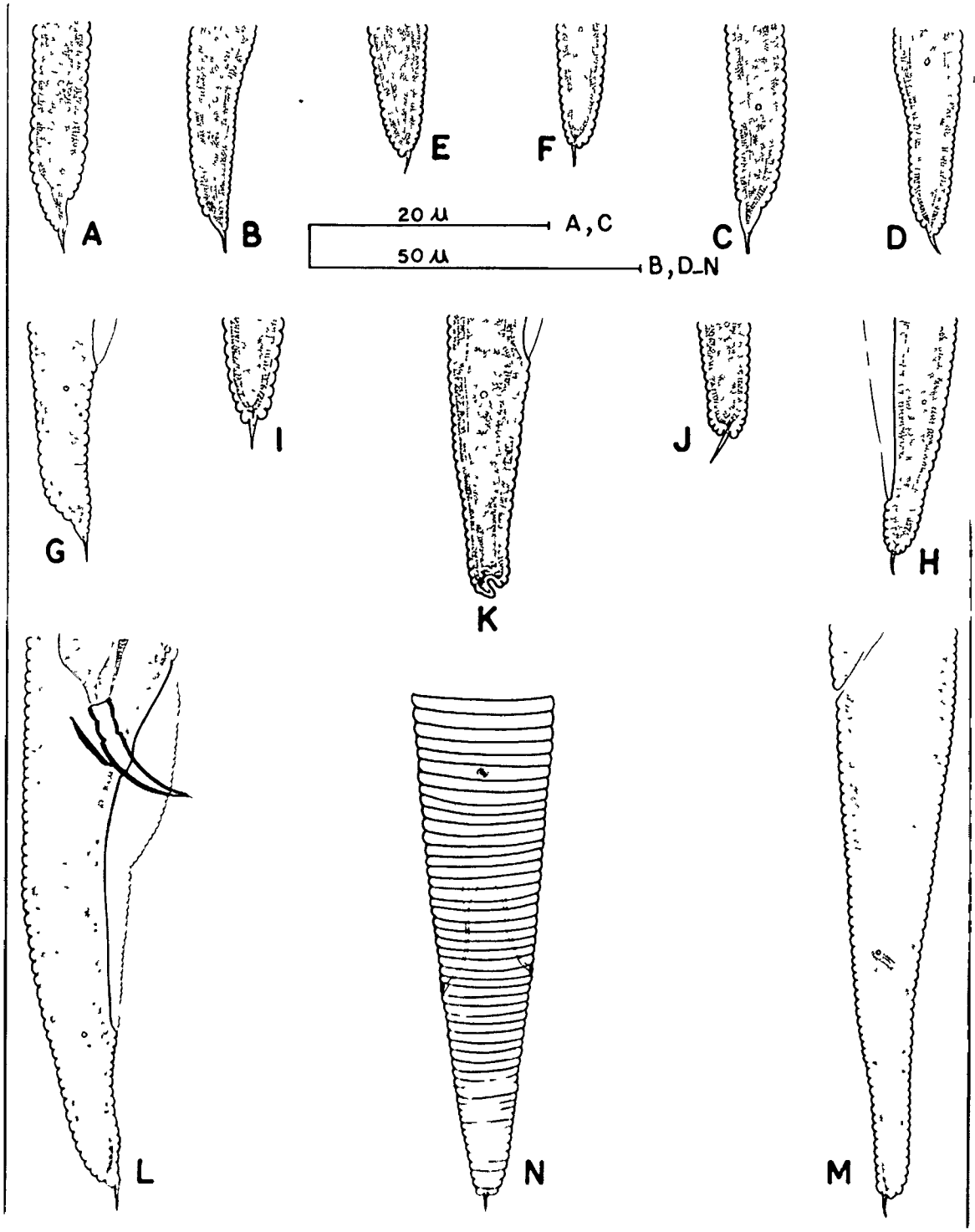
J. Female tail tip with curved mucro.

K. Male tail notched.

L. Male tail lateral.

M. Female tail lateral.

N. Female tail dorso-ventral.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P L A T E: V.

Figs. A-N — HEAD ENDS AND ESOPHAGEAL REGIONS

A. Head end of female.

B & C. Head ends of male.

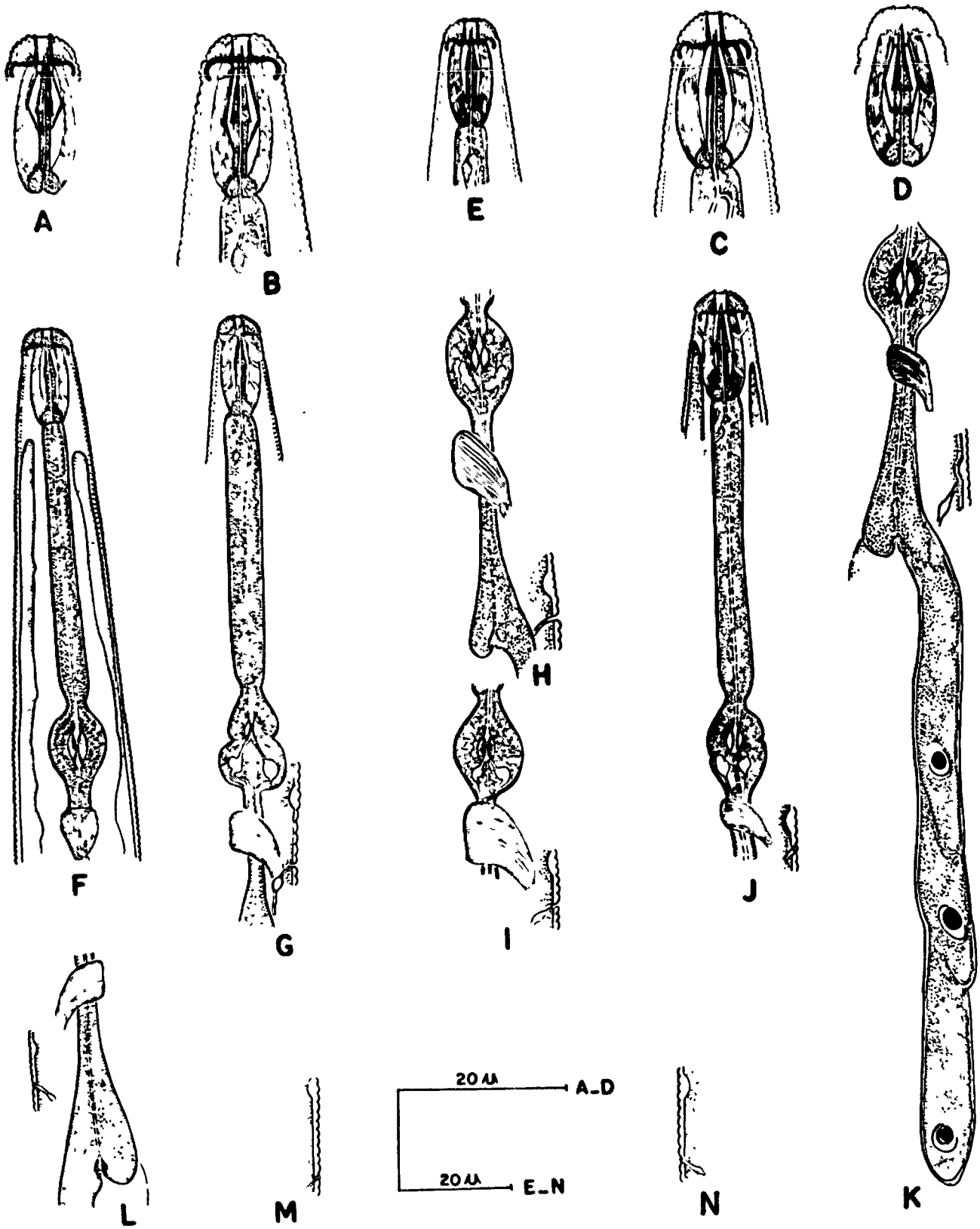
D. Head end of female showing head skeleton.

E. Head end of female showing opening of dorsal-esophageal gland in the lumen of procorpus.

F. Anterior region of female in dorso-ventral view showing lateral hypodermal chords.

G-K. Different regions of esophagus showing esophageal lumen, valvular apparatus, esophageal gland lobes, their ampullae and orifices.

H-N. Relative positions of Hemizonid and Excretory pore.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P L A T E: VI-A.

Figs. A-L — CROSS-SECTIONS OF H. ORYZAE AT DIFFERENT LEVELS

A. En face view

B. C.S. below the basal plate showing spear muscles.

C. C.S. at level of spear knobs.

D. C.S. at level of the anterior region of median bulb.

E. C.S. at level of middle of median bulb.

F. C.S. through the isthmus.

G. C.S. through dorsal-esophageal gland lobe.

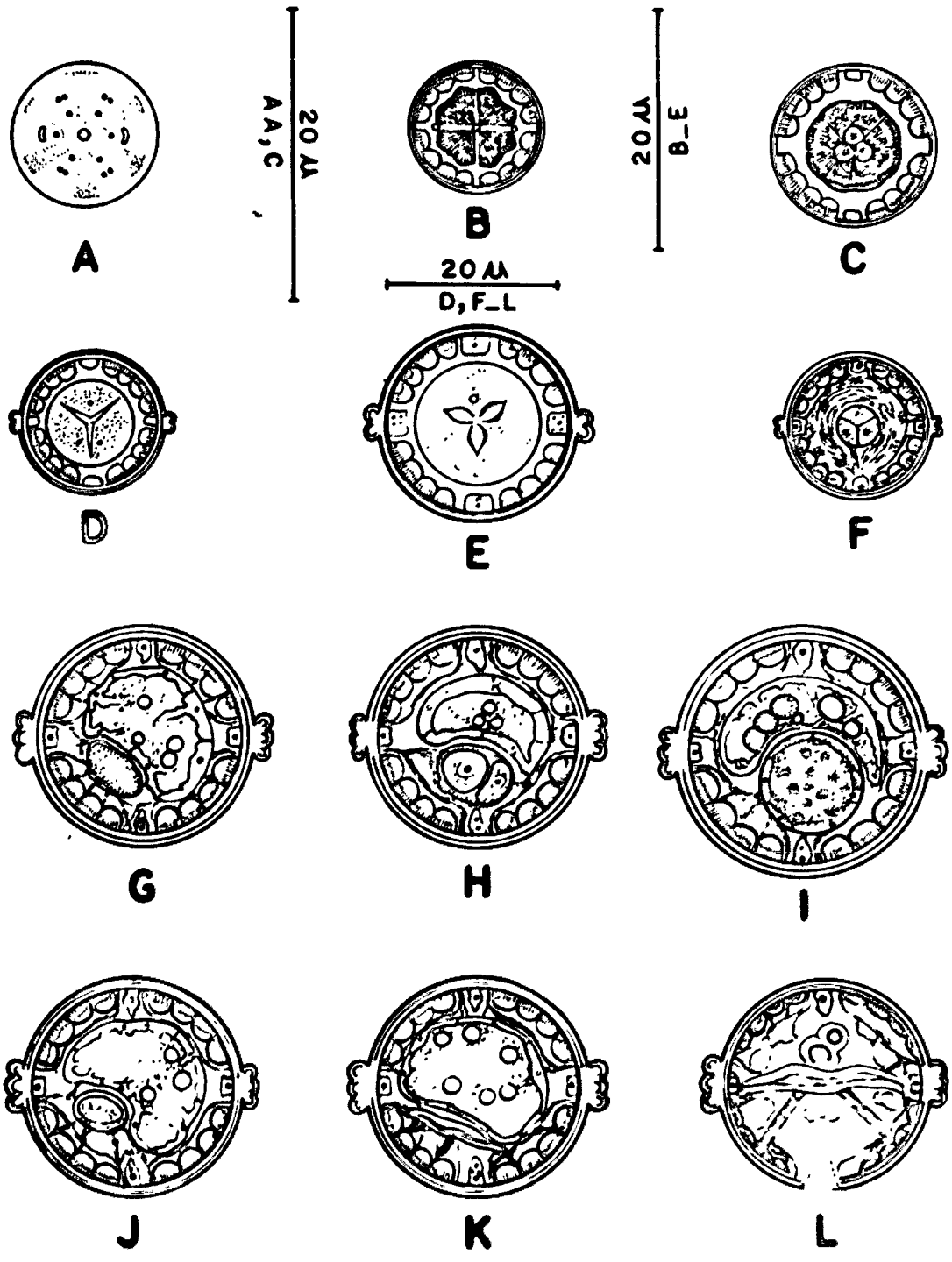
H. C.S. through the ovary.

I. C.S. through spermatheca.

J. C.S. through the proximal part of the uterus.

K. C.S. through the distal part of the uterus.

L. C.S. at level of anus.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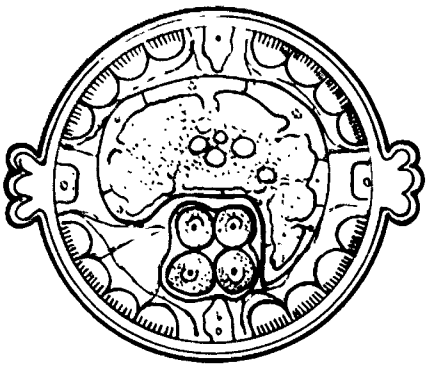
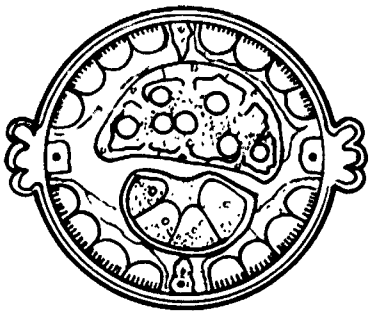
P L A T E: VI-B.

Figs. M-S — CROSS-SECTIONS OF H. ORYZAE AT DIFFERENT LEVELS

M-O	C.S. through testis.
P.	C.S. through vas deferens.
Q.	C.S. through the head of spicules.
R & S.	C.S. through the middle of spicules.



M



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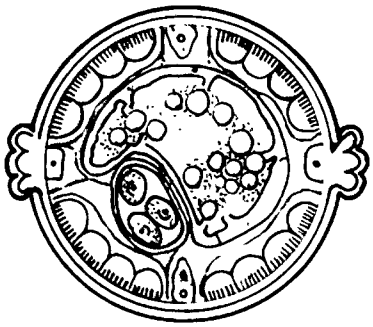

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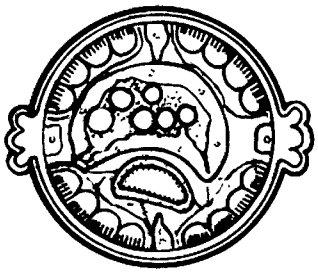

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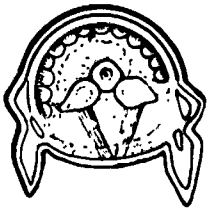

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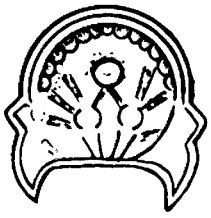

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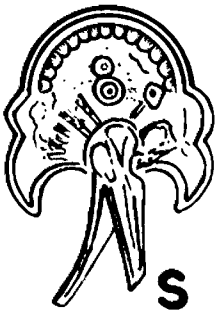


S

P L A T E: VII.

Figs. A-I MUSCULATURE

Somatic muscles:

A. Somatic muscles in anterior part of body.

B. Somatic muscles in vulval region.

C. Somatic muscles in anal region.

Specialized muscles:

D-G. Vulval muscles.

H. Anal muscles.

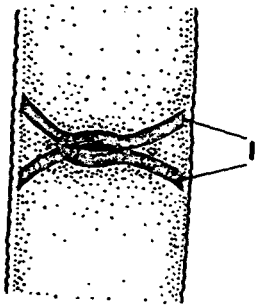
I. Male copulatory muscles.

1. Constrictor vulvae
2. Dilator vulvae
3. Anal muscles
4. Latero-ventral retractor spiculi
5. Latero-dorsal retractor spiculi
6. Right external protractor spiculi
7. Left external protractor spiculi
8. Internal protractor spiculi
9. Anterior protractor spiculi
10. Right retractor gubernaculi
11. Left retractor gubernaculi
12. Right protractor gubernaculi
13. Left protractor gubernaculi
14. Right seductor gubernaculi
15. Left seductor gubernaculi
16. Copulatory muscles

A

B

C



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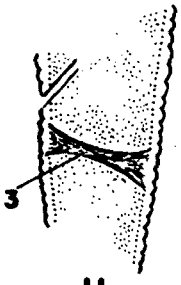
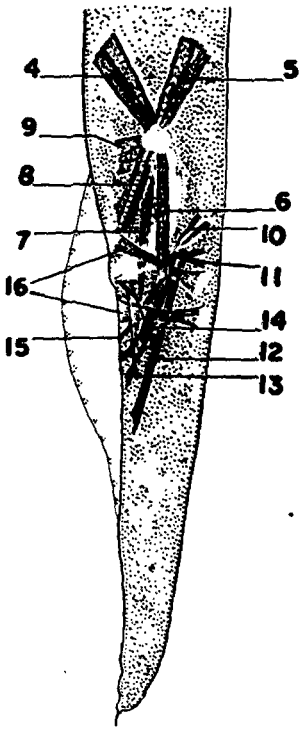
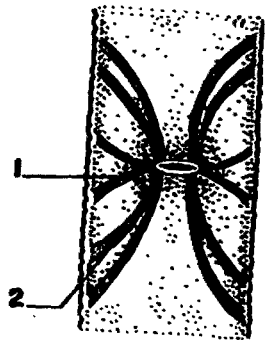


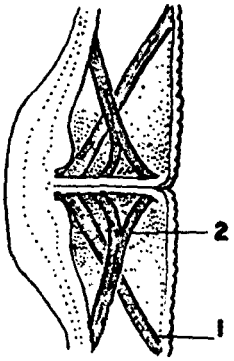
H



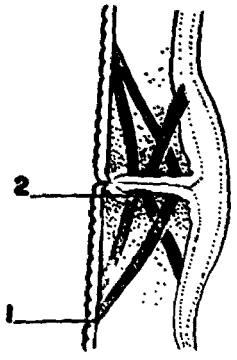
I



E



F



G

P L A T E: VIII.

Figs. A-H NERVOUS AND EXCRETORY SYSTEMS.

A. Nerve ring complex.

B. Nerve ring and associated neuro-sensory cells.

C.& D. Nerve ring and associated neuro-sensory cells at different levels.

E. Neuro-sensory cells in the vulval region.

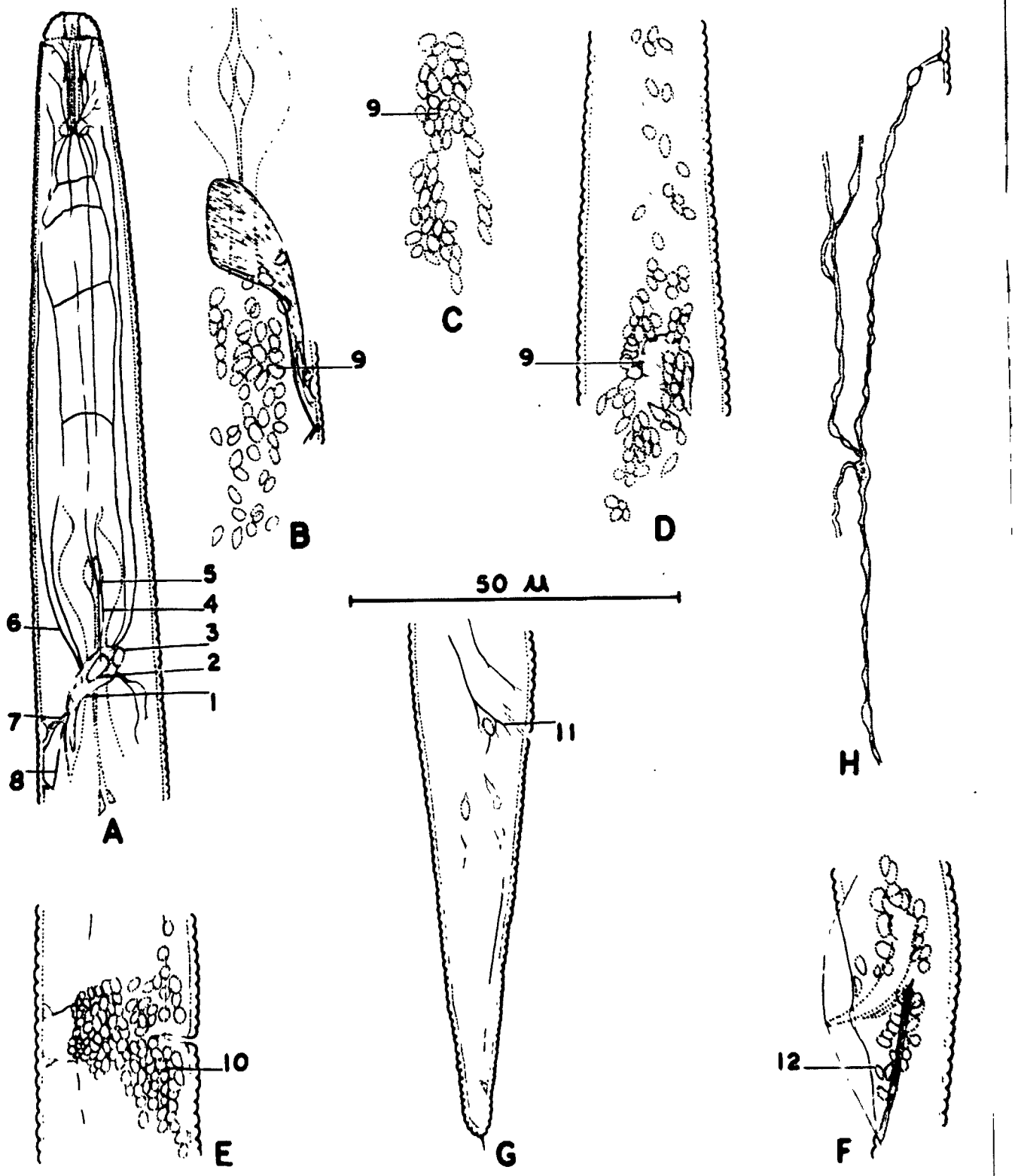
F. Neuro-sensory cells in the cloacal region.

G. Neuro-sensory cells and nerves in the anal region.

H. Excretory system.

1. Nerve ring
2. Lateral cephalic ganglion
3. Dorsal ganglion
4. Lateral cephalic-sensory nerve
5. Lateral cephalic-sensory nerve
6. Ventral cephalic-sensory nerve
7. Nerve to hemizonid
8. Nerve to excretory pore

9-12. Neuro-sensory cells


A
B
C
D
E
F
G
H
1
2
3
4
5
6
7
8
9
9
9
10
11
12
50 µ

P L A T E: IX.

Figs. A-L FEMALE GONADS

A. Uterine part.

A_1. Anterior sexual branch.

A_2. Posterior sexual branch.

B. Anterior spermatheca.

C. Posterior spermatheca.

D. Developing spermatheca.

E & F. Elongate spermathecae.

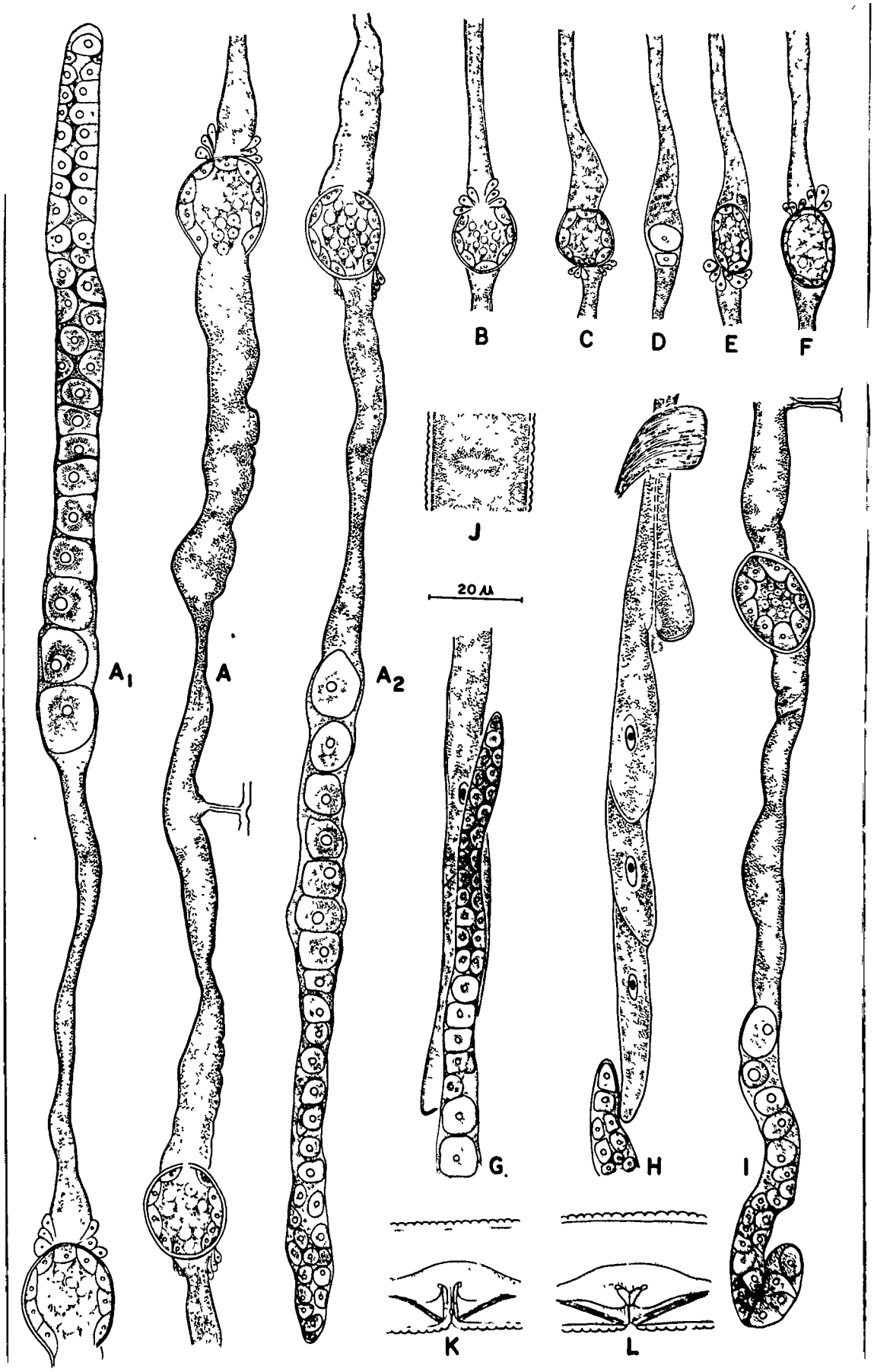
G. Ovary reaching the glandular part of esophagus.

H. Ovary touching the tip of the gland overlap.

I. Posterior gonad showing a part of ovary reflexed.

J. Vulva (in surface view).

K & L. Vulva (lateral) showing structure of the vagina at two levels.


A1
A
A2
B
C
D
E
F
J
20 µ
G
H
I
K
L

P L A T E: X.

Figs. A-J. MALE GONAD

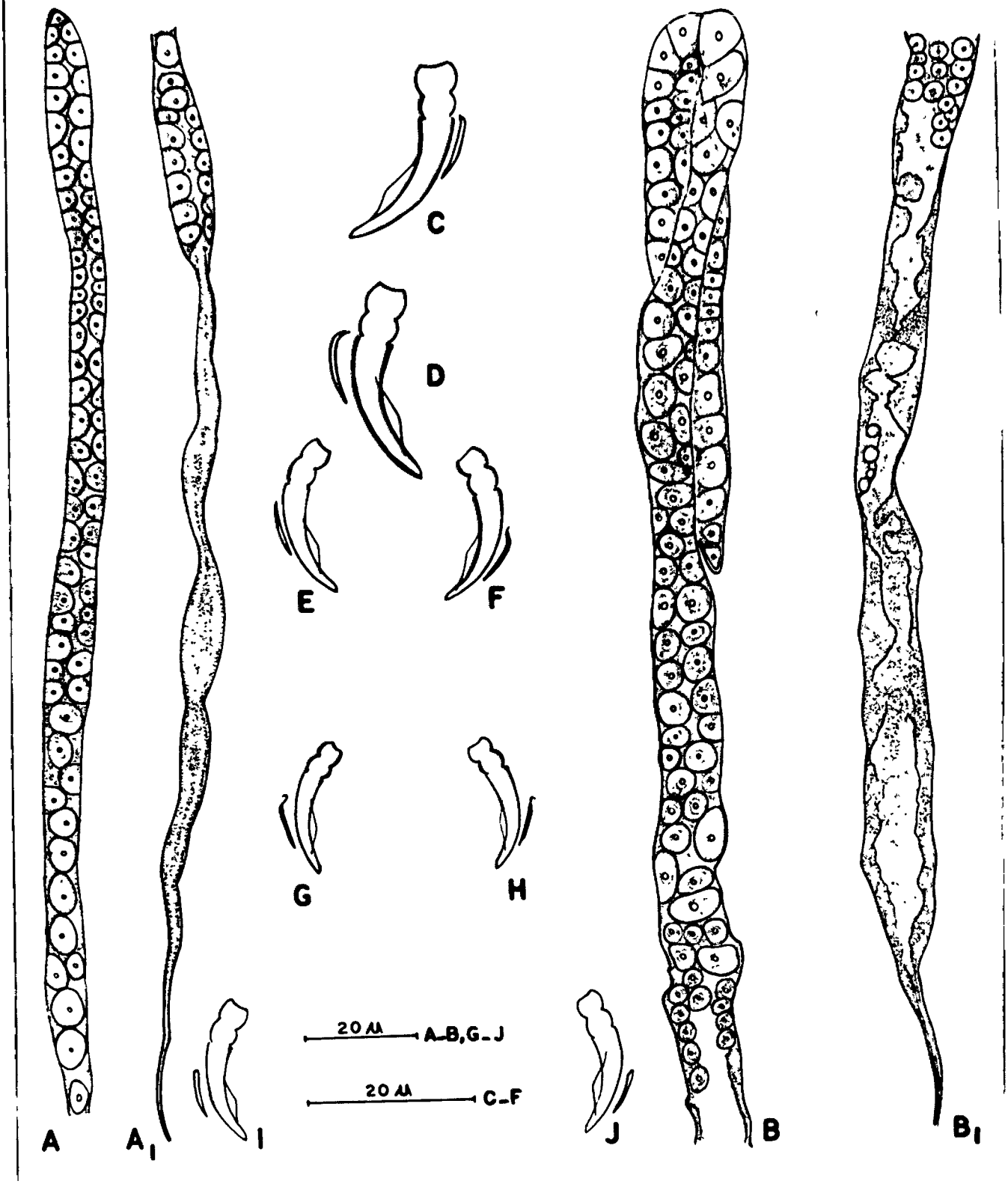
A. Testis.

A_1. Vas deferens and ejaculatory duct.

B. Reflexed testis.

B_1. Hinder part of the same

C-J. Spucules and gubernaculum.


A
A1
I
C
D
E
F
G
H
20 M
A-B, G-J
20 M
C-F
J
B
B1

P L A T E: XI.

Figs. A-H — *Ditylenchus claviceudatus* n. sp.

A. Esophageal region of female.

B. Esophageal region of female (immature).

C. Head end of female.

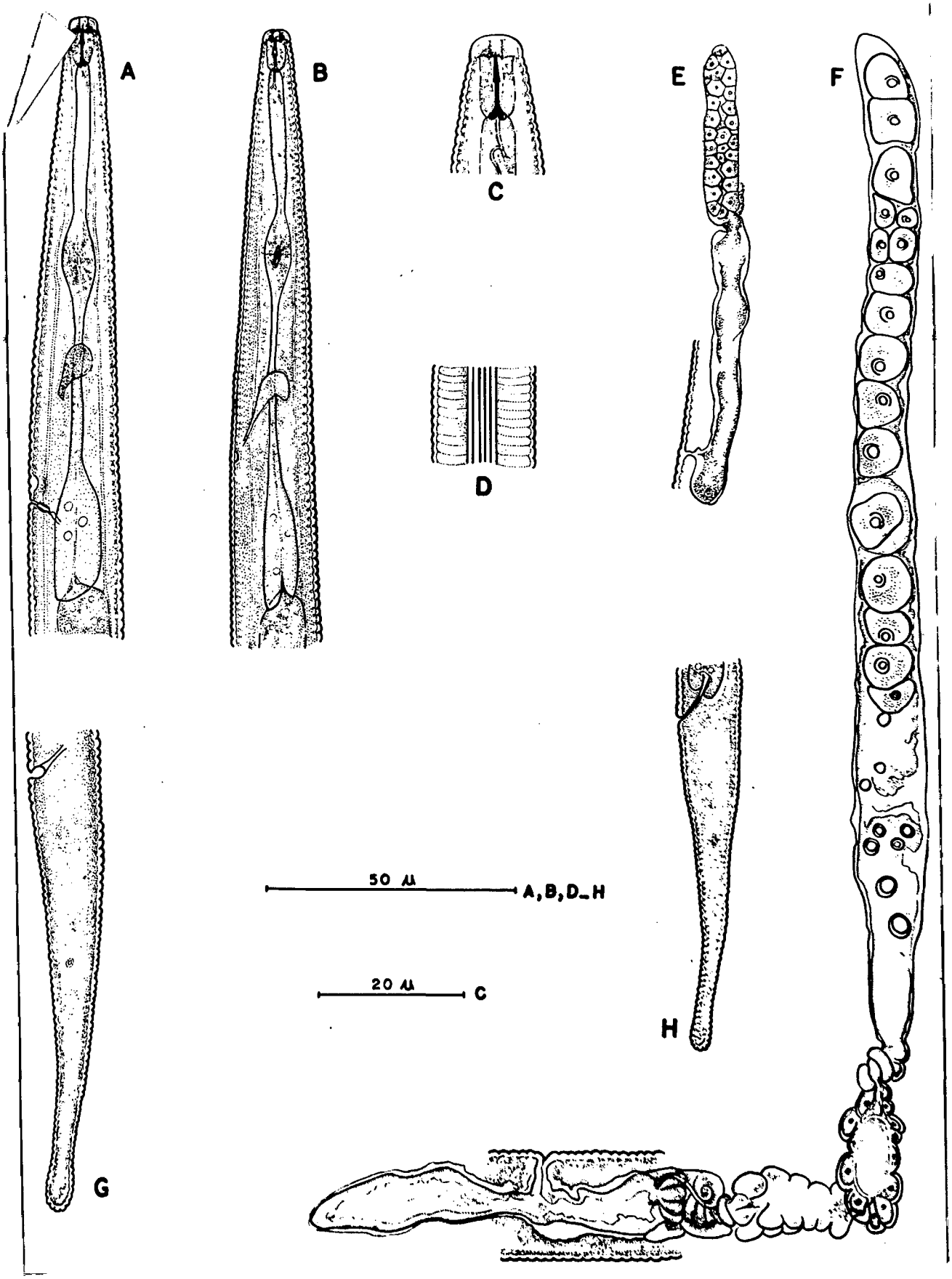
D. Lateral fields.

E. Developing gonad of female.

F. Female gonad (mature).

G. Female tail.

H. Tail of immature female.


A
B
C
D
E
F
G
H
50 µ
A,B,D-H
20 µ
C

P L A T E: XII.

Figs. A-C *Helicotylenchus retusus* Siddiqi and Brown, 1964

A. Esophageal region of female.

B. Vulval region.

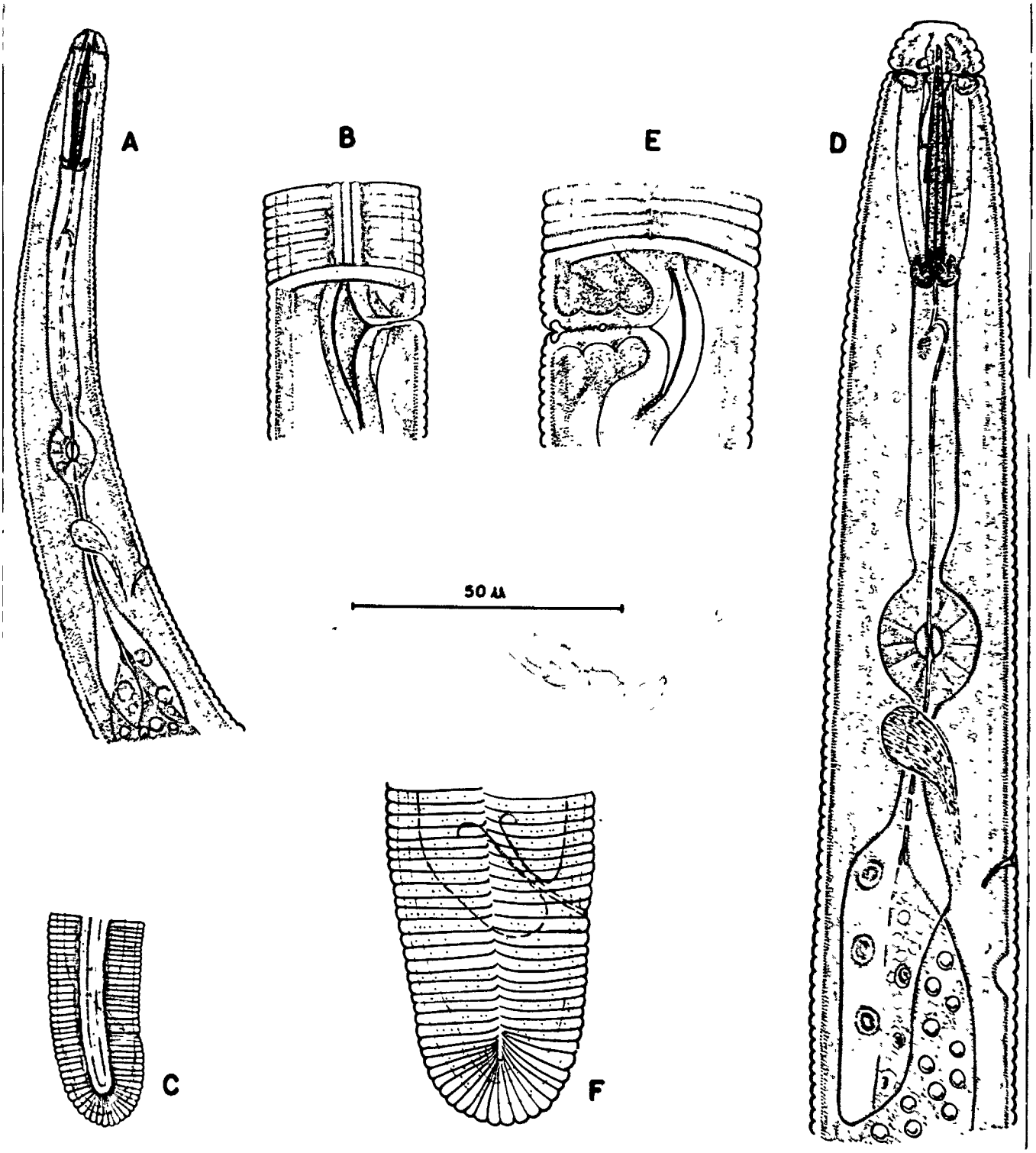
C. Female tail.

Figs. D-F *Hoplolaimus neoformis* n. sp.

D. Esophageal region of female.

E. Vulval region.

F. Female tail.


A
B
E
D
50 µ
C
F

P L A T E: XIII.

Figs. A-E *Helicotylenchus jhansiensis* n. sp.

A. Esophageal region of female.

B. Head end of female.

C. Female gonad (anterior).

D. Female tail (showing lateral incisures).

E. Female tail.

Figs. F-J *Helicotylenchus implicatus* n. sp.

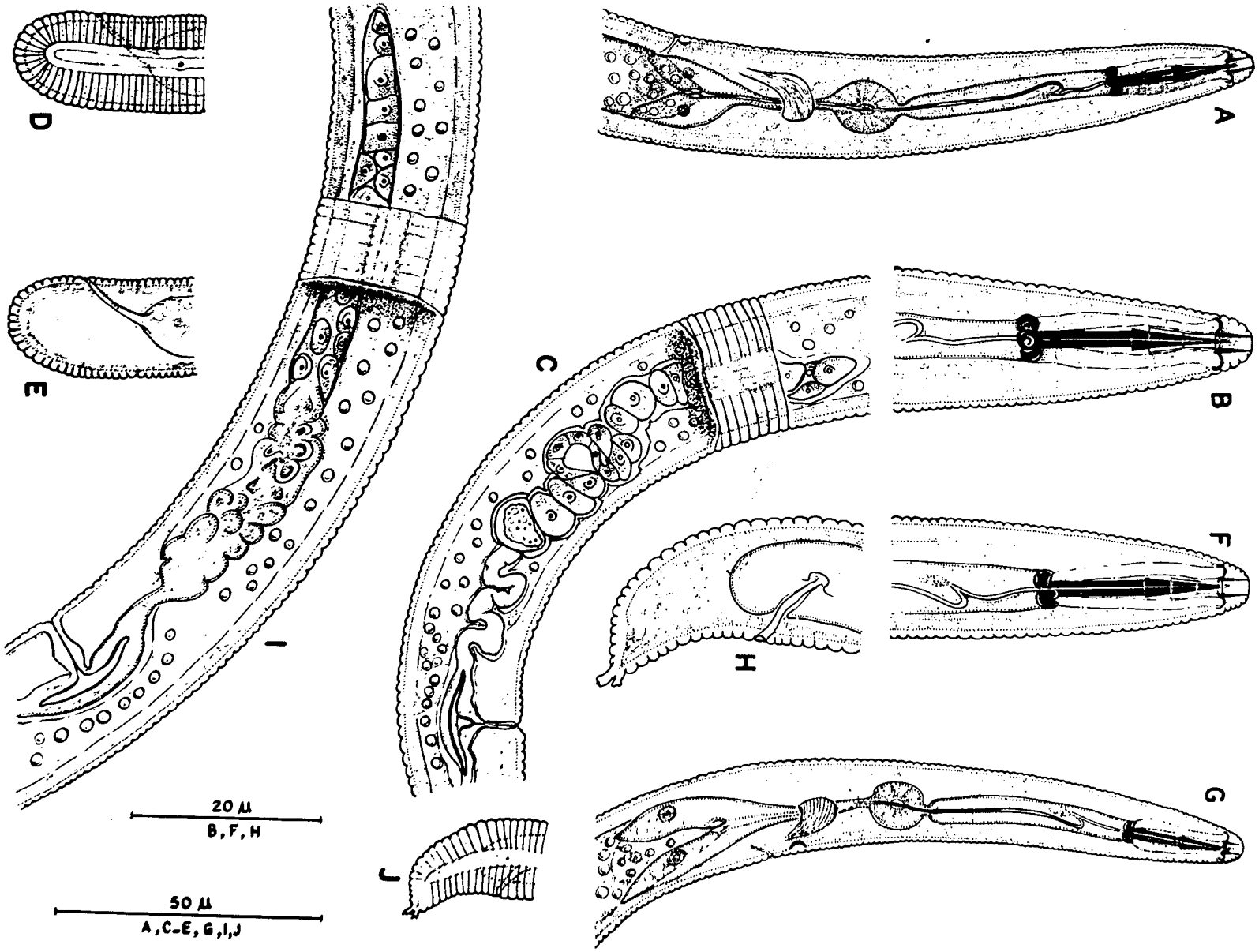
F. Head end of female.

G. Esophageal region of female.

H. Female tail.

I. Female gonad (anterior).

J. Female tail (showing lateral incisures).


A
B
C
D
E
F
G
H
I
J
20 µ
B, F, H
50 µ
A, C-E, G, I, J

P L A T E: XIV.

Figs. A-F *Helicotylenchus novus* n. sp.

A. Esophageal region of female.

B. Head end of female.

C. Female gonad (posterior).

D. Lateral fields.

E. Female tail.

F. Female tail (showing lateral incisures).

Figs. G-L *Helicotylenchus acuticaudatus* n. sp.

G. Head end of female.

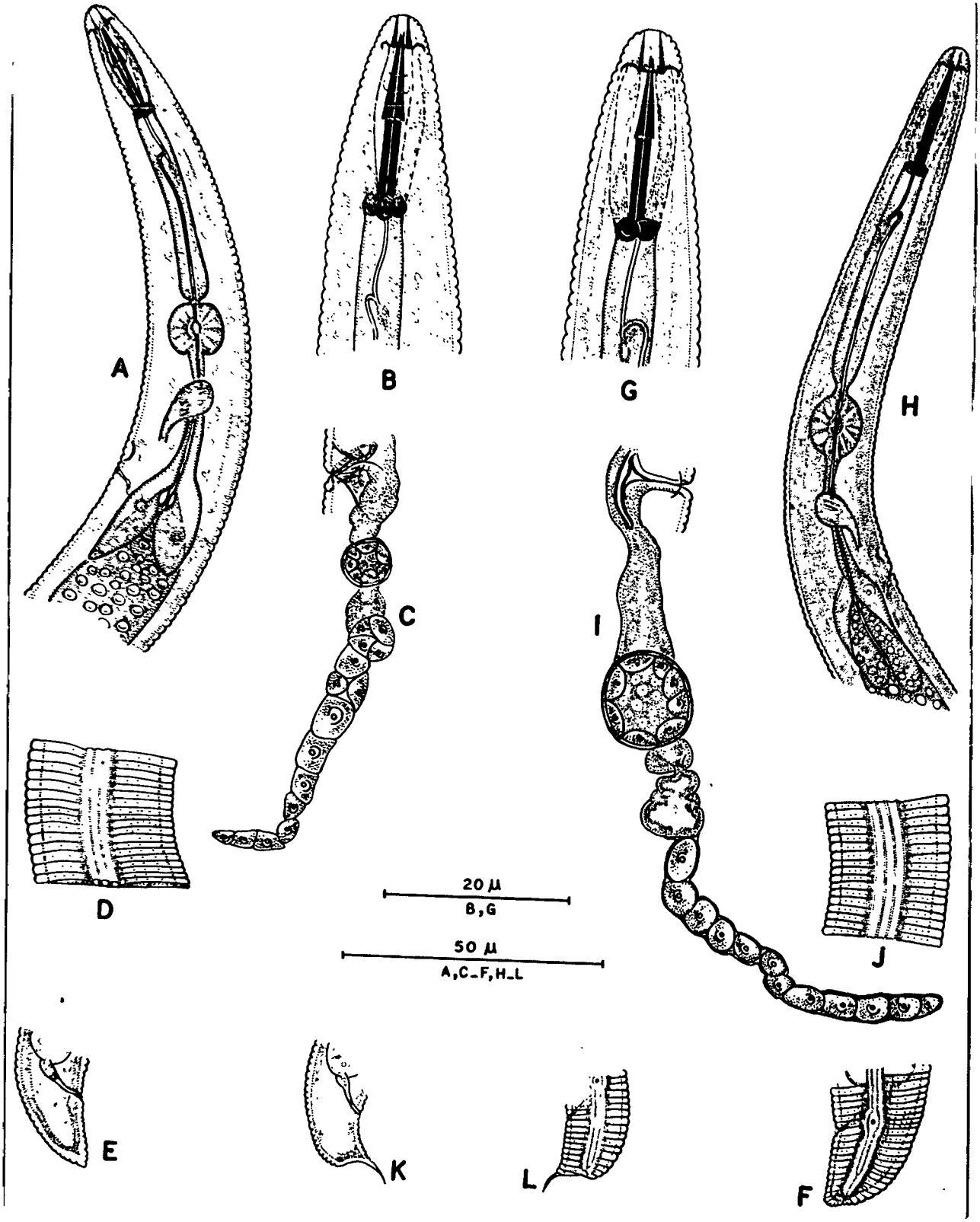
H. Esophageal region of female.

I. Female gonad (posterior).

J. Lateral fields.

K. Female tail.

L. Female tail (showing lateral incisures).


A
B
G
H
C
I
D
J
20 µ
B,G
50 µ
A,C-F,H-L
E
K
L
F

P L A T E: XV.

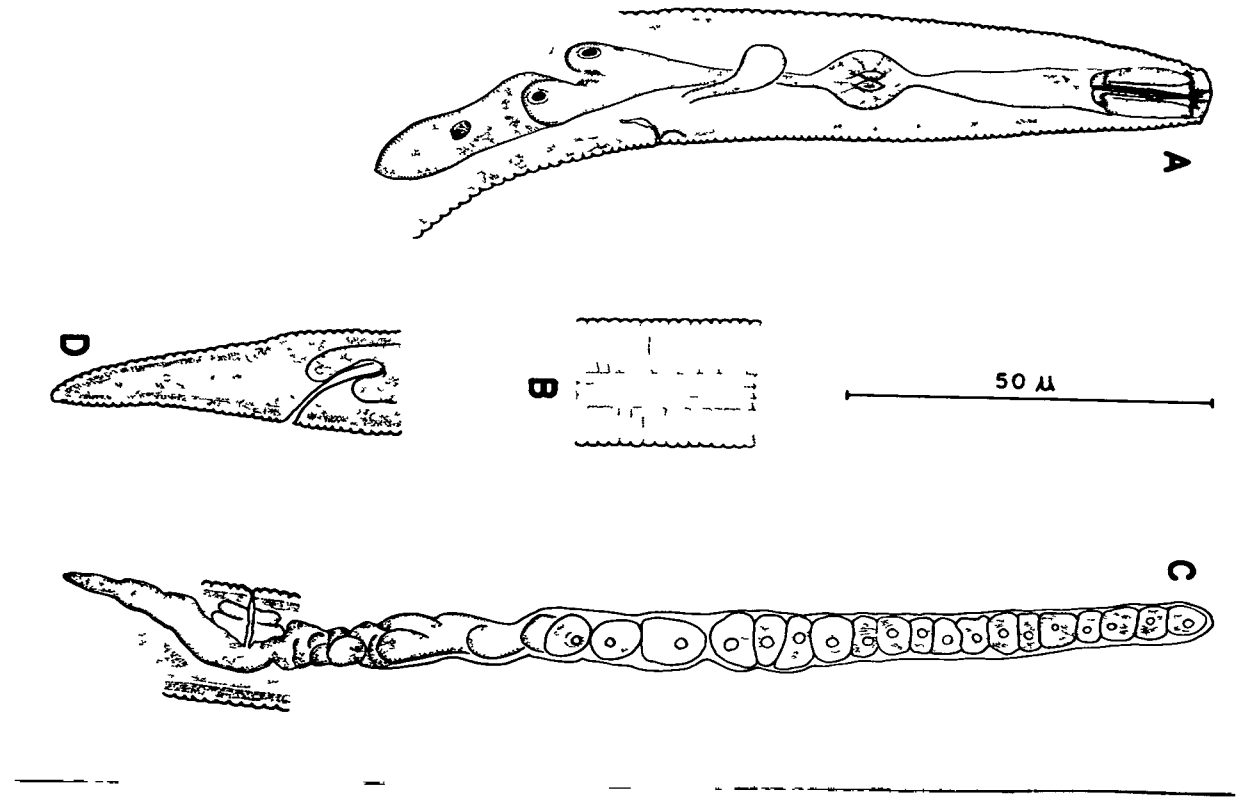
Figs. A-D *Pratylenchus geiseri* n. sp.

A. Esophageal region of female.

B. Lateral fields.

C. Female gonad.

D. Female tail.


A
B
C
D
50 µ

P L A T E: XVI.

Figs. A-E *Hirschmanniella gracilis* (de Man, 1880) Luc and Goodey, 1963.

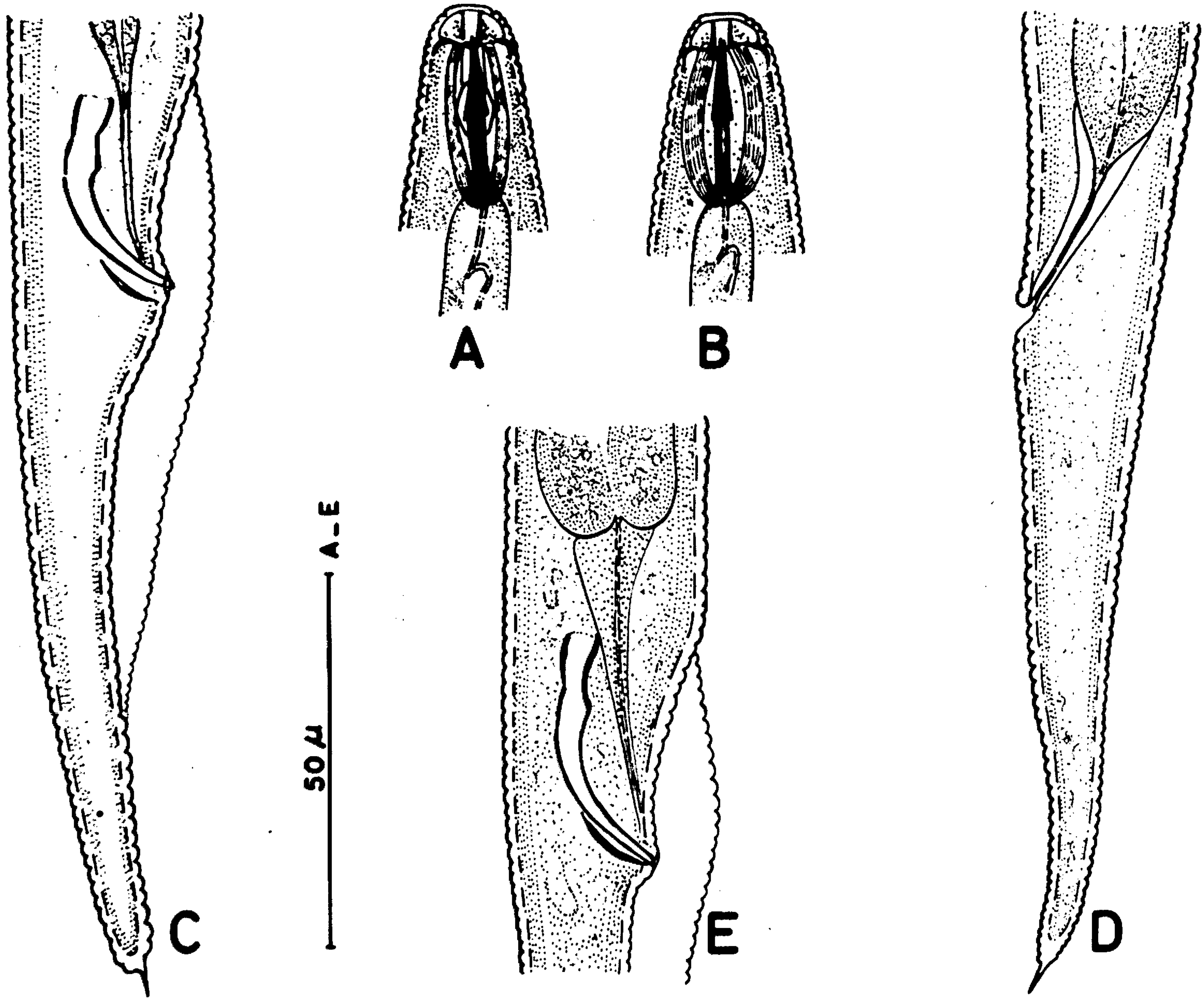
A. Head end of female.

B. Head end of male.

C. Female tail.

D. Male tail.

E. Cloacal region of male.


A
B
C
D
E
50μ
A_E

P L A T E: XVII.

Figs. A-M *Hirschmanniella timmi* n. sp.

A. Head end of female.

B. Head end of female (magnified).

C. Head end of male.

D. Œsophageal region of female.

E. Lateral fields.

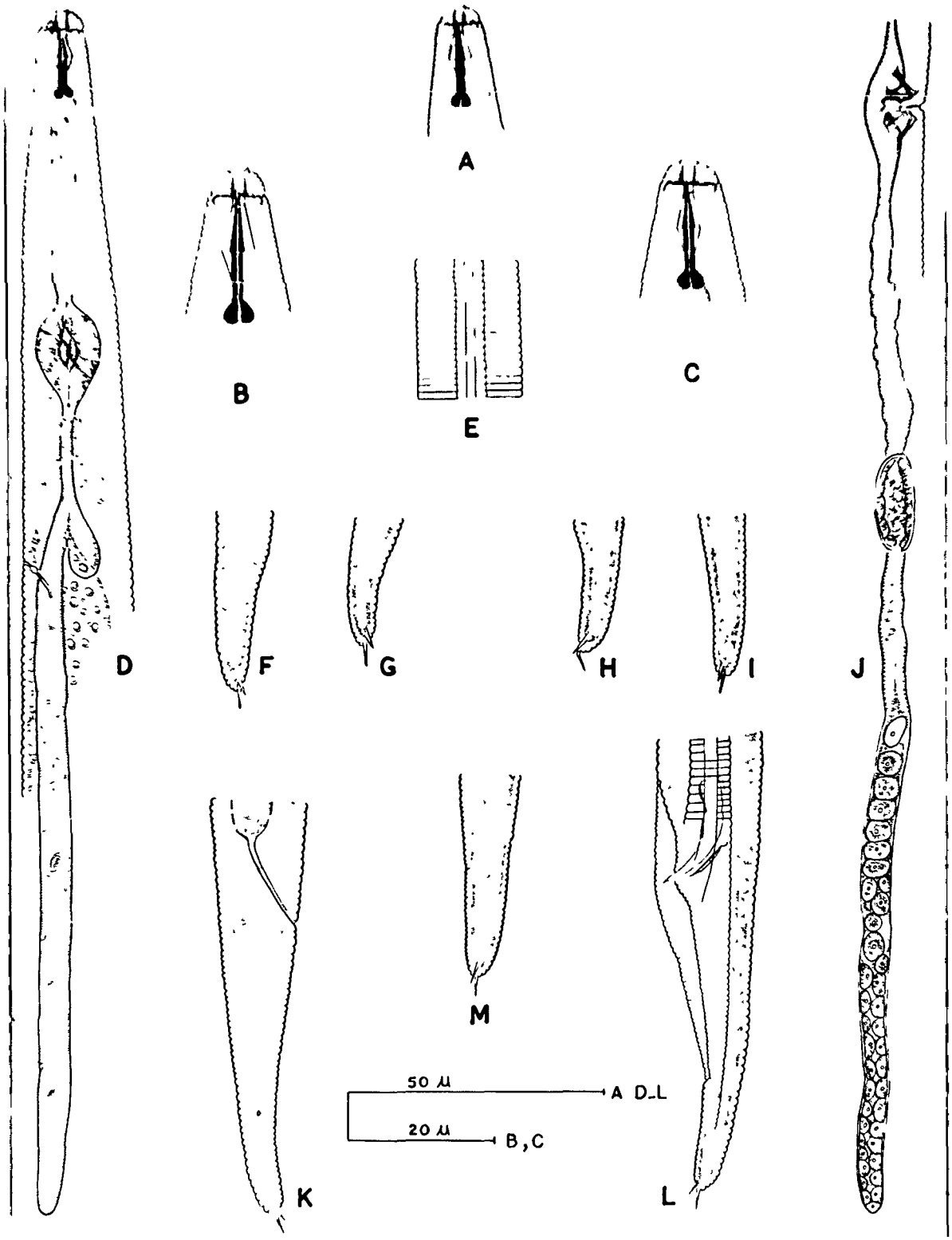
F-I. Female tail tips.

J. Female gonad (posterior).

K. Female tail (lateral).

L. Male tail (lateral).

M. Female tail tip (dorso-ventral).


A
B
C
D
E
F
G
H
I
J
K
L
M
50 µ
A D-L
20 µ
B, C

P L A T E: XVIII.

Figs. A-M *Hirschmanniella indica* n. sp.

A. Œsophageal region of female.

B & C. Head ends of females.

D. Head end of male.

E. Œsophago-intestinal junction of female.

F. Lateral fields.

G. Female gonad (posterior).

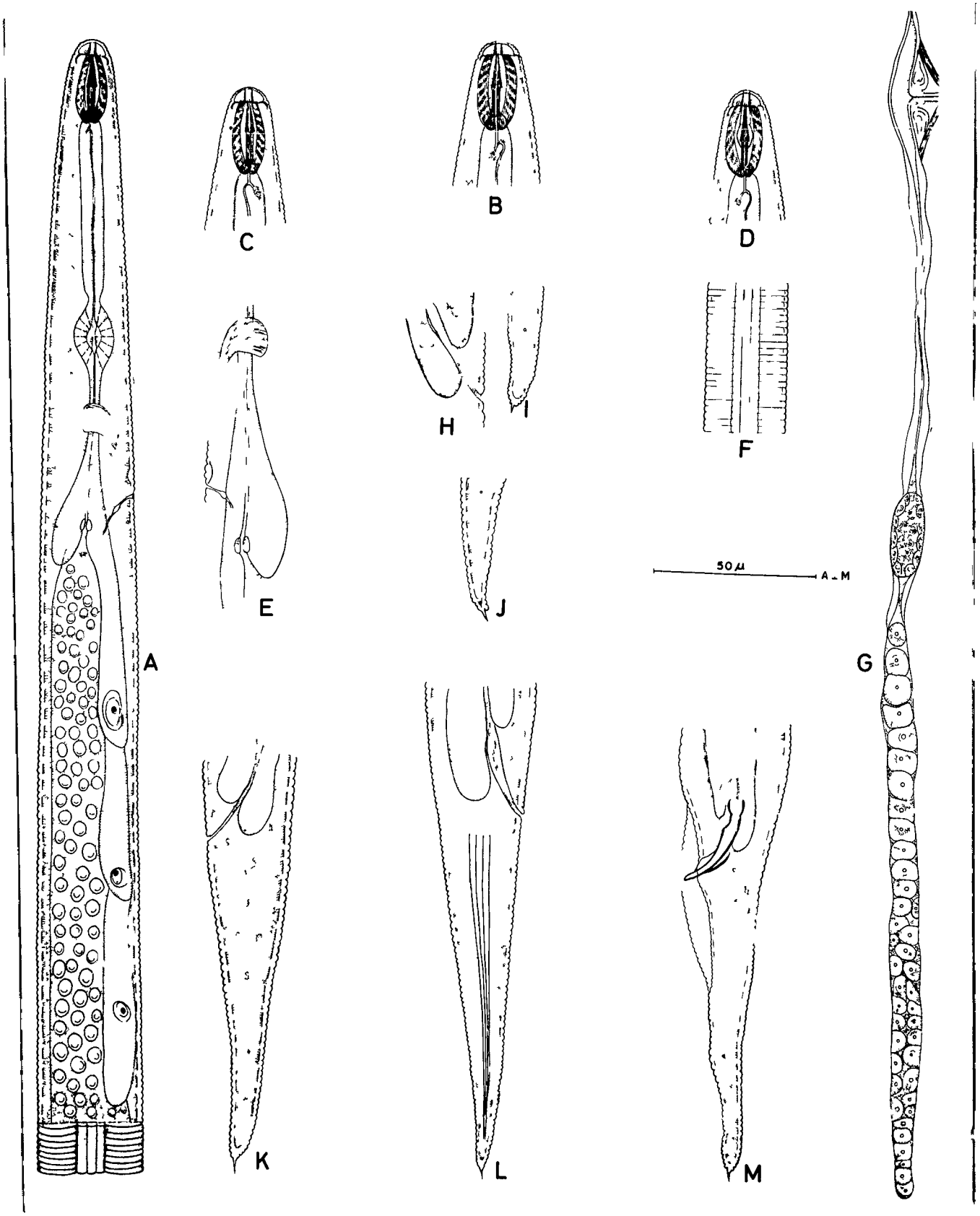
H. Anal region of female.

I & J. Female tail tips.

K. Female tail.

L. Female tail (showing lateral incisures).

M. Male tail.


A
B
C
D
E
F
G
H
I
J
K
L
M
50 µ
A - M

P L A T E: XIX.

Figs. A-E *Paratylenchus oryzae* n. sp.

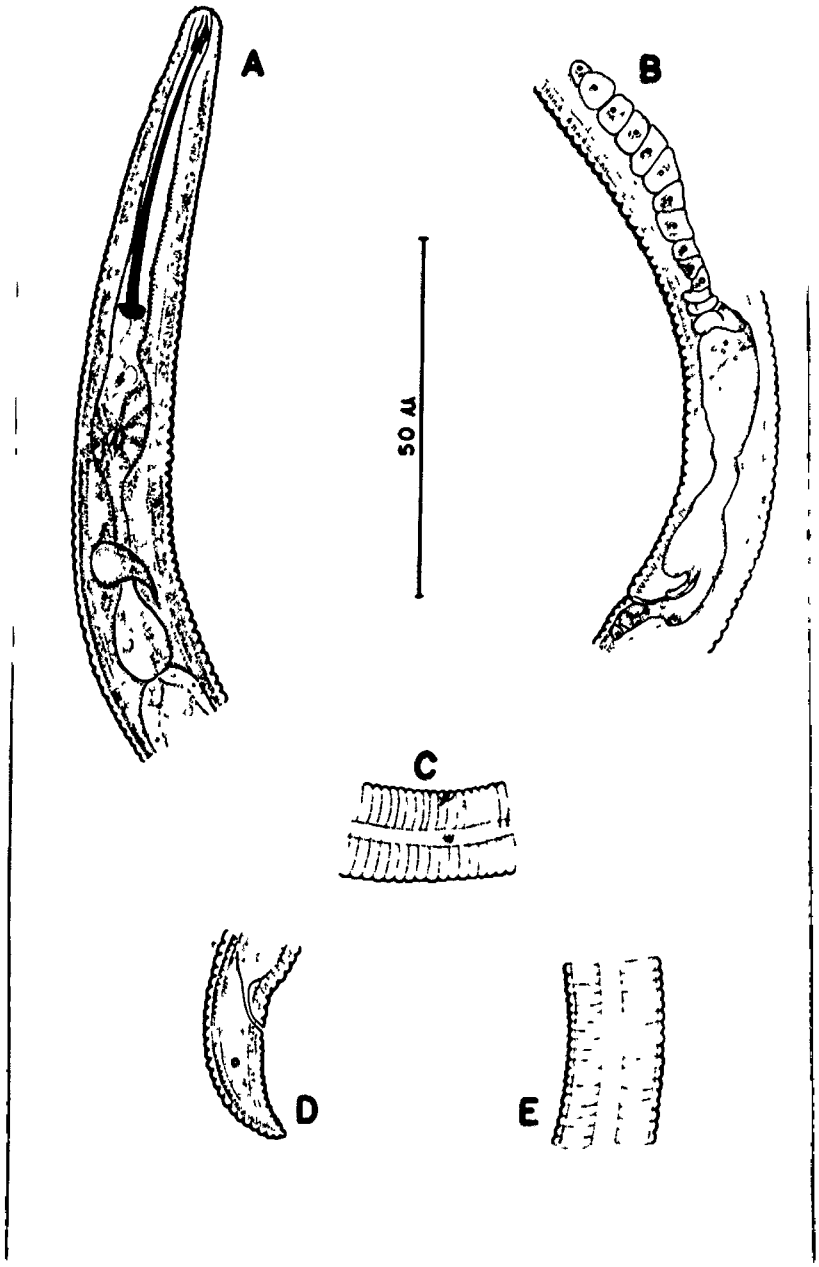
A. Esophageal region of female.

B. Female gonad.

C. Lateral fields (anterior).

D. Female tail.

E. Lateral fields (near middle).


A
B
50 µ
C
D
E

P L A T E: XX.

Figs. A-H *Hexatylus viviparus* T. Goodey, 1926

A. Esophageal region of female.

B. Esophago-intestinal junction.

C. Head end of female.

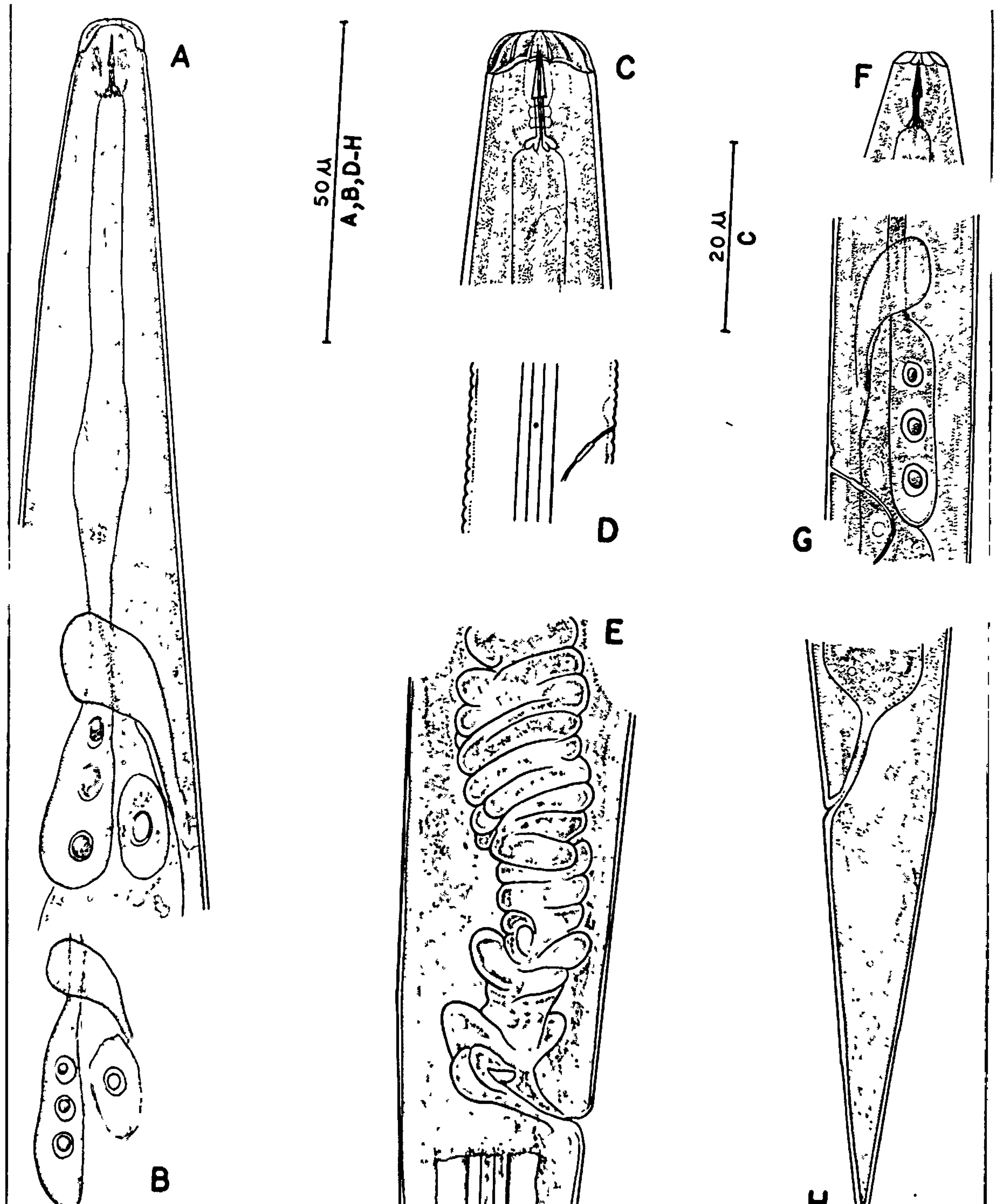
D. Excretory pore region of female.

E. Vulval region.

F. Lip region of female.

G. Female esophageal region.

H. Female tail.


A
B
50 µ
A, B, D-H
C
D
E
20 µ
C
F
G
H

P L A T E: XXI.

Figs. A-C *Nothotylenchus acuticaudatus* n. sp.

A. Esophageal region of female.

B. Female gonad.

C. Female tail.

Figs. D-I *Sakia oryzae* n. sp.

D. Head end of female.

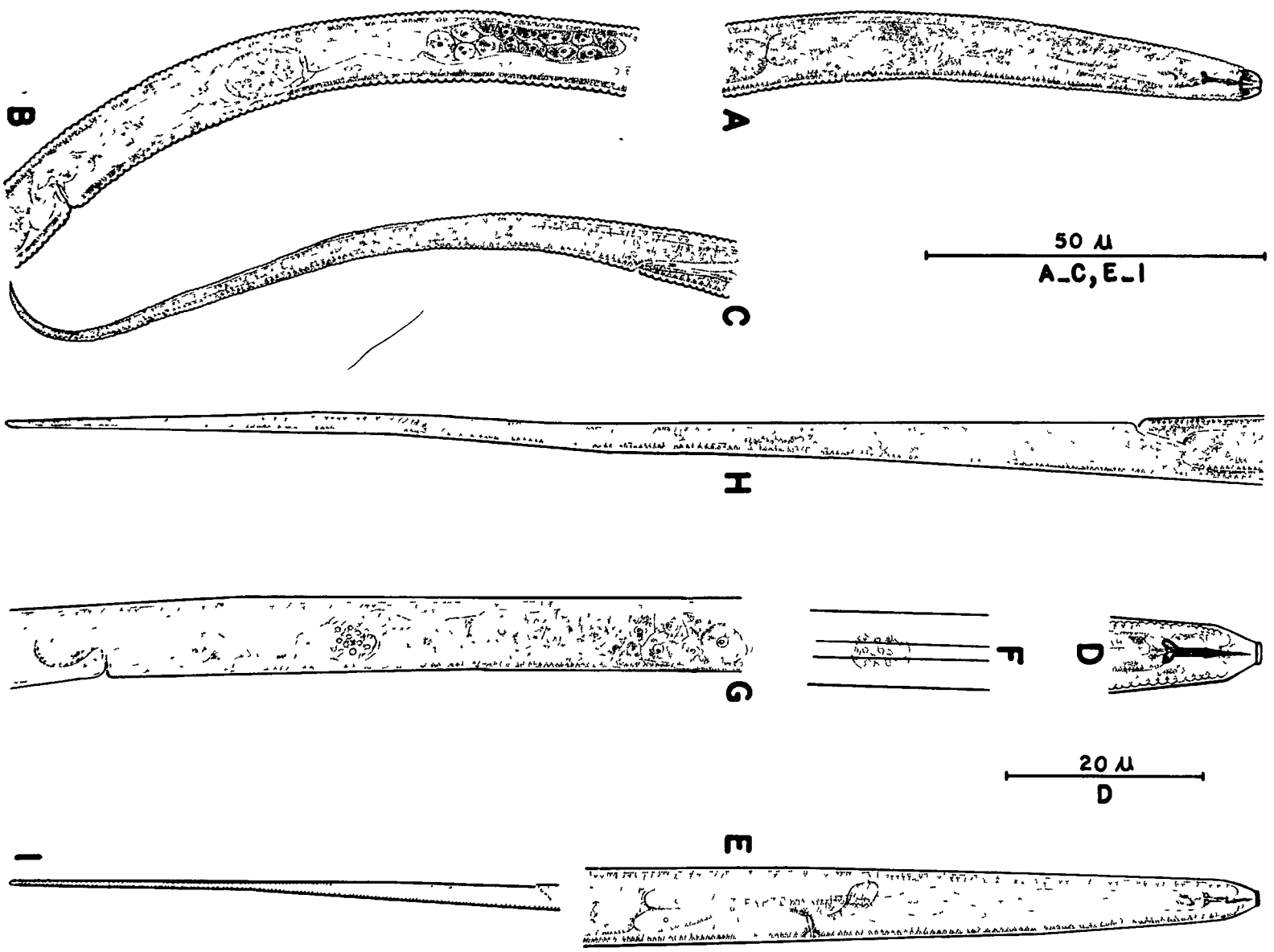
E. Esophageal region of female.

F. Lateral fields.

G. Female gonad.

H. Female tail (magnified).

I. Female tail.


B
A
C
50 µ
A-C, E-I
H
G
F
D
20 µ
D
I
E

P L A T E: XXII.

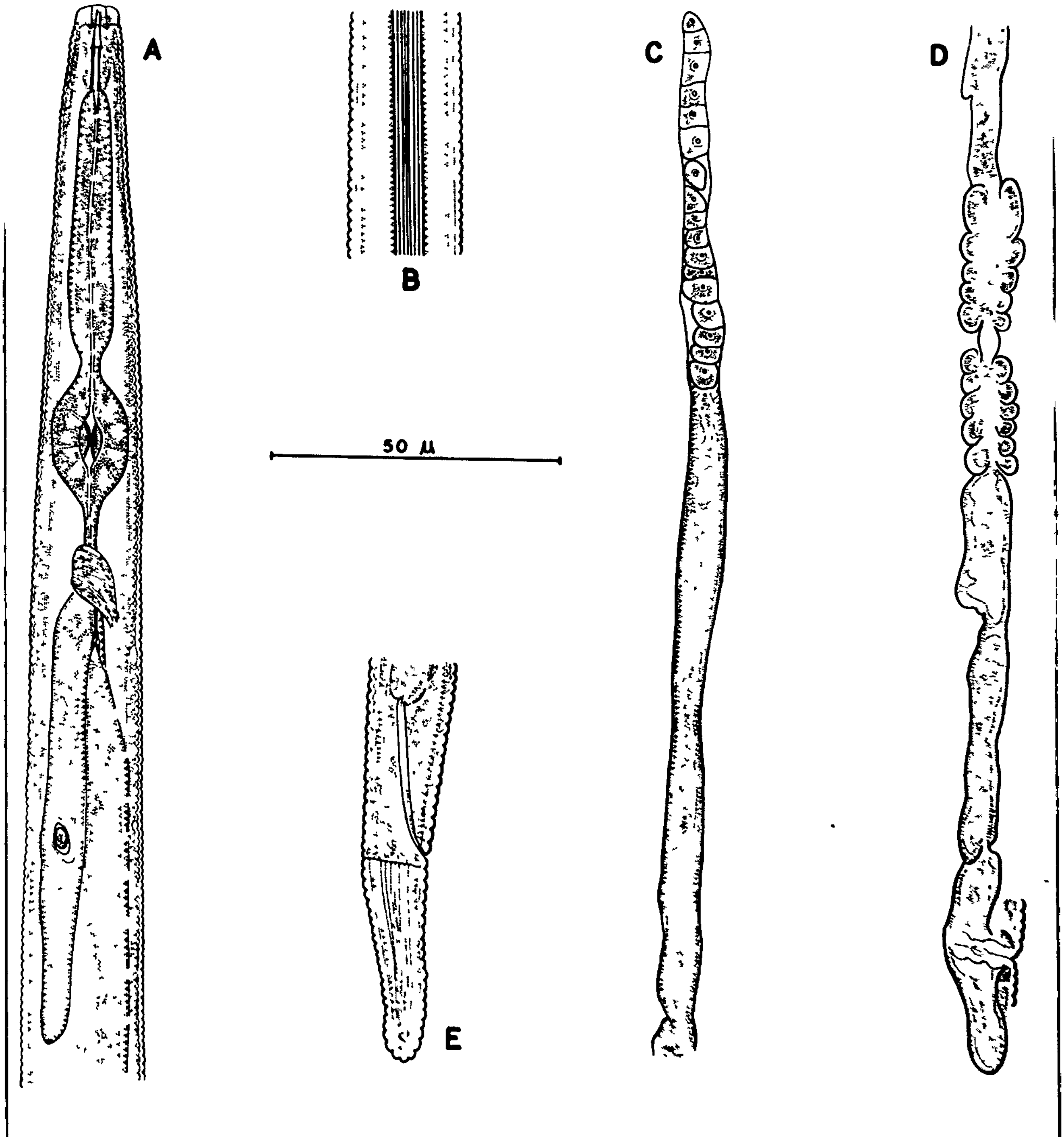
Figs. A-E *Aphelenchus mashhoodi* n. sp.

A. Esophageal region of female.

B. Lateral fields.

C-D. Female gonad.

E. Female tail.


A
B
C
D
50 µ
E

P L A T E: XXIII.

Figs. B-E *Seinura basiri* n. sp.

B. Head end of female.

C. Esophageal region of female.

D. Female gonad.

E. Female tail.

Figs. A, F-J *Seinura indica* n. sp.

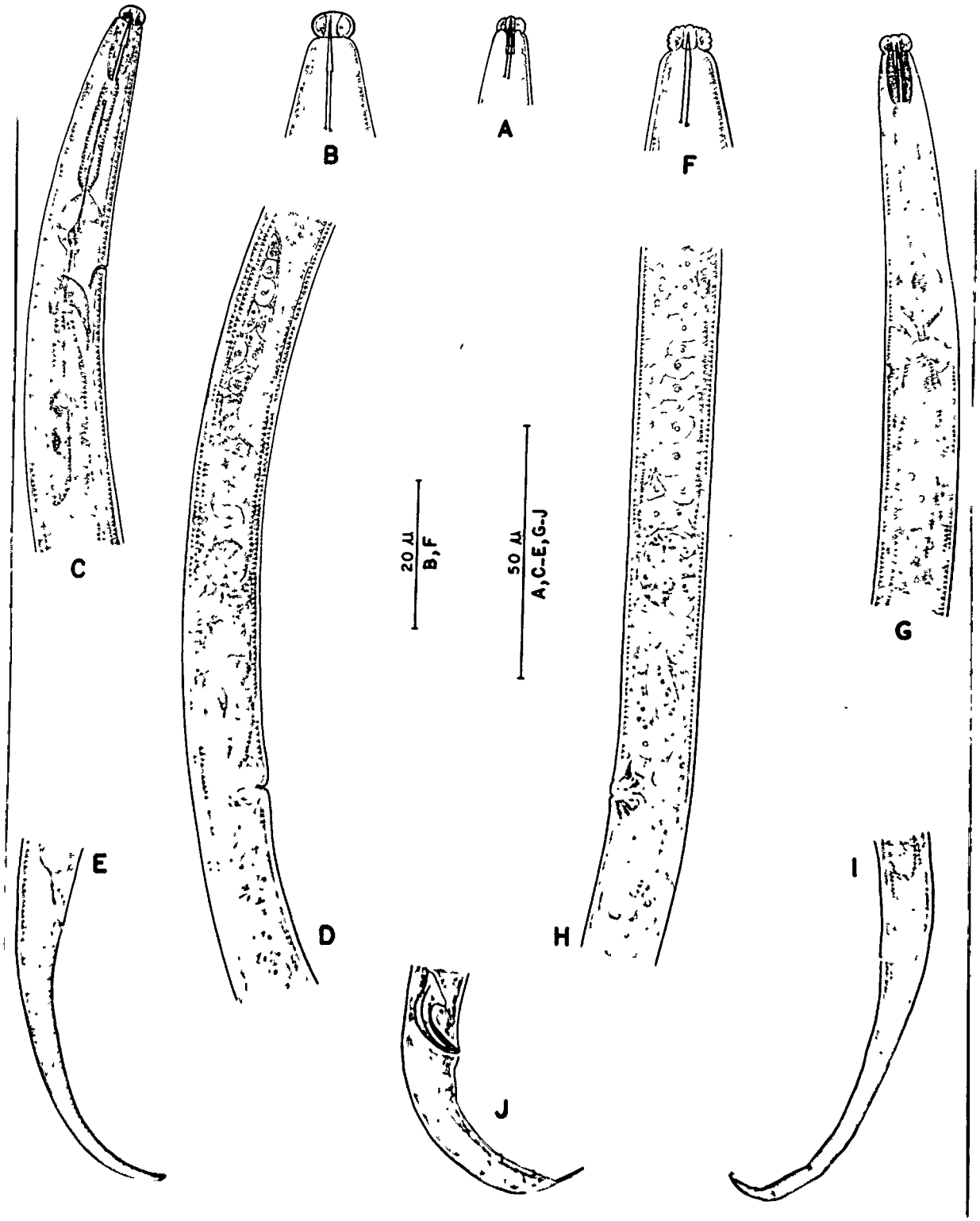
A & F. Head end of females.

G. Esophageal region of female.

H. Female gonad.

I. Female tail.

J. Male tail.


A
B
C
D
E
F
G
H
I
J
20 µ
B, F
50 µ
A, C–E, G–J

P L A T E: XXIV.

Figs. A-F *Discolaimium indicum* n. sp.

A. *En face* view.

B. C.S. through basal plate.

C. Head end of female.

D. Basal expanded part of esophagus.

E. Female tail.

F. Female gonad (anterior).

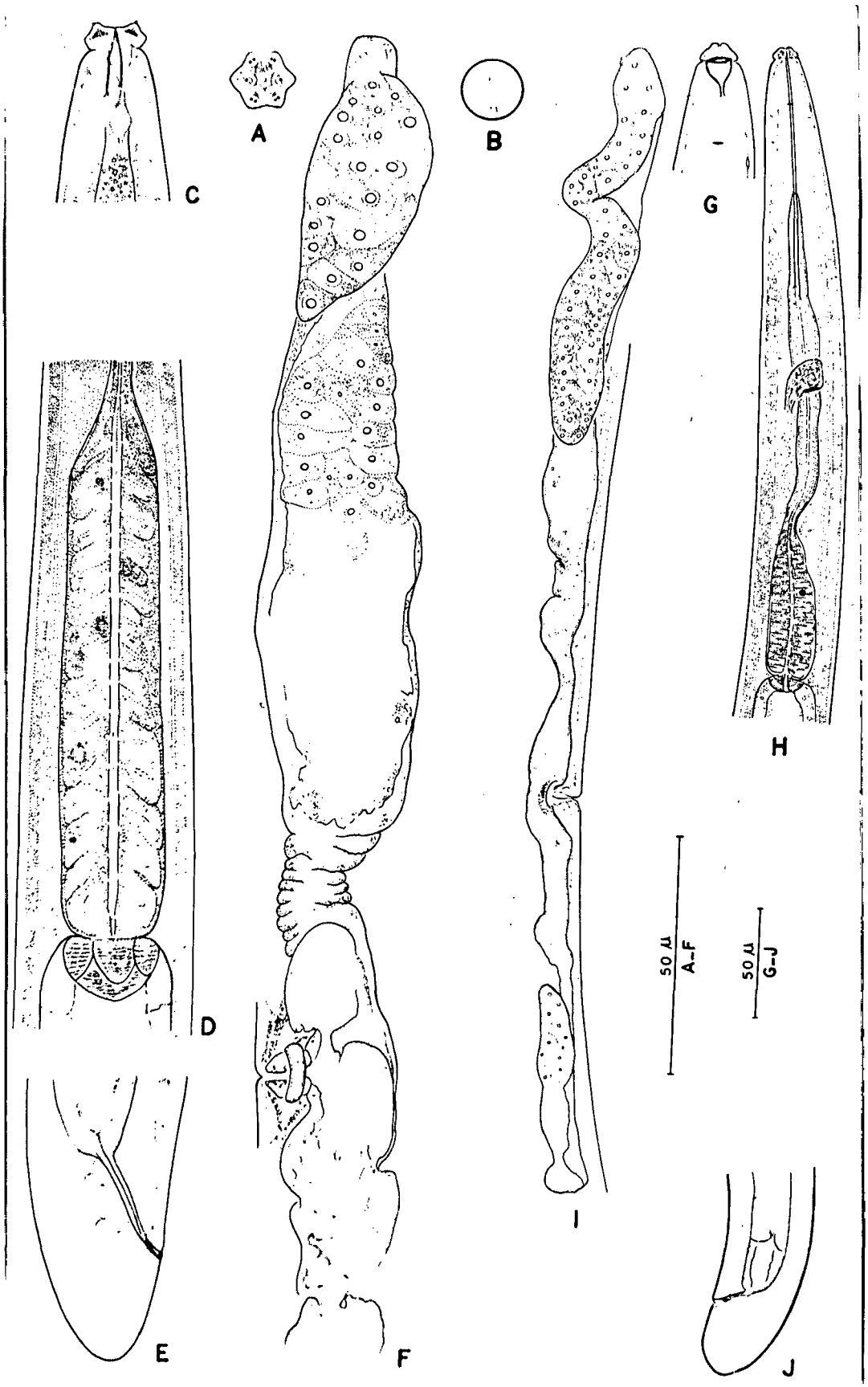
Figs. G-J *Paralongidorus parvus* n. sp.

G. Head end of female (showing amphids).

H. Esophageal region of female.

I. Female gonad.

J. Female tail.


A
B
C
D
E
F
G
H
I
J
50 µ
A-F
50 µ
G-J

P L A T E: XXV .

Figs. A-D *Leptonchus* [illegible] n. sp.

A. Esophageal region of female.

B. Head end of female.

C. Female gonad (posterior).

D. Female tail (dorso-ventral).

Figs. E & F *Oudsielle gracilis* Jairajpuri, 1967

E. Esophageal region of female.

F. Female tail.

Figs. G-I *Dionchus obtusus* Cobb, 1913

G. Anterior end of female.

H. Female gonad.

I. Female tail.

Figs. J-P *Dionchus oryzae* n. sp.

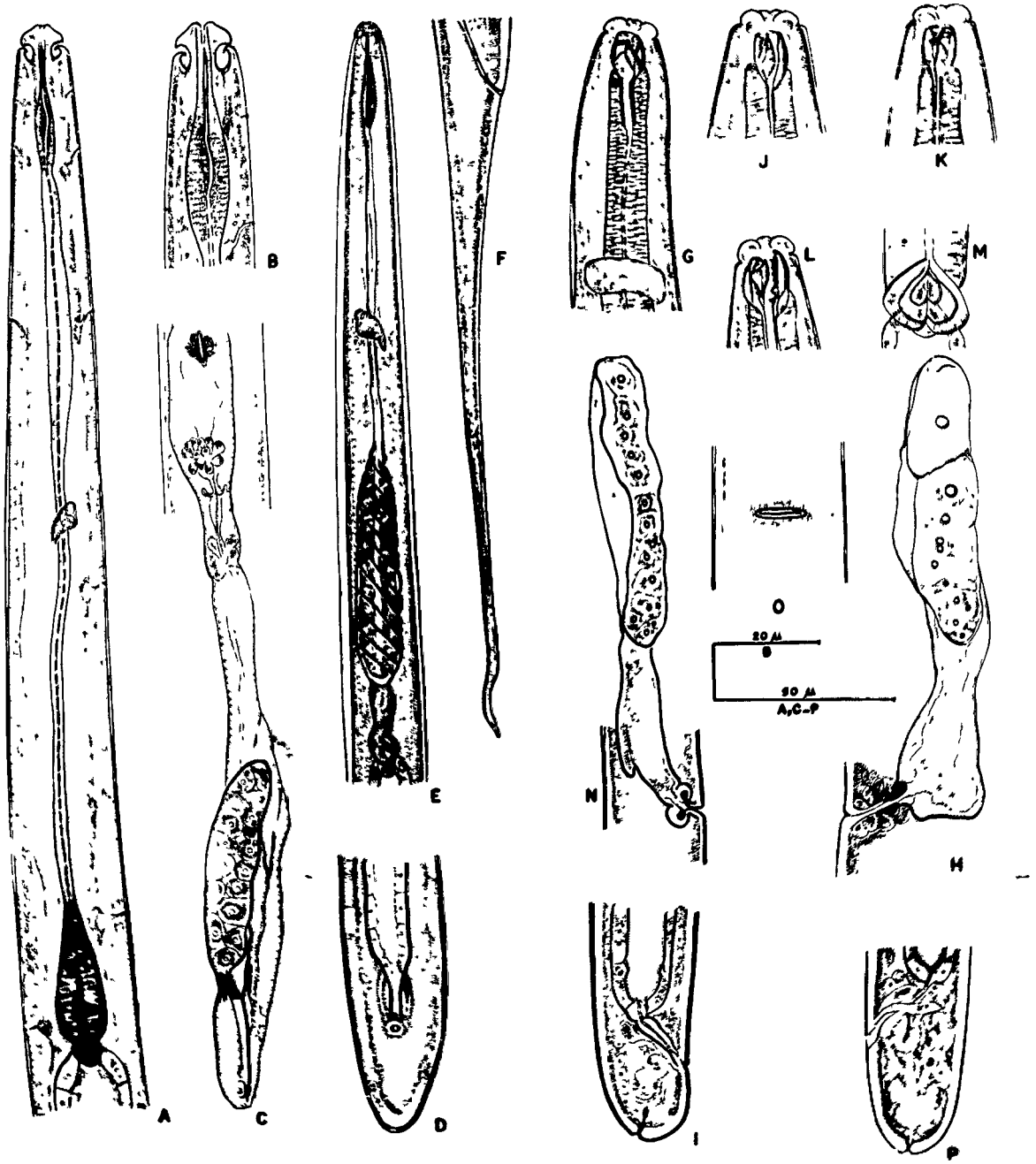
J-L. Head end of females.

M. Esophago-intestinal junction of females.

N. Female gonad.

O. Vulva (dorso-ventral).

P. Female tail.


A
B
C
D
E
F
G
J
K
L
M
N
O
H
I
P
20 µ
B
50 µ
A,C-P

P L A T E: XXVI.

Figs. A-F *Miconchus indicus* n. sp.

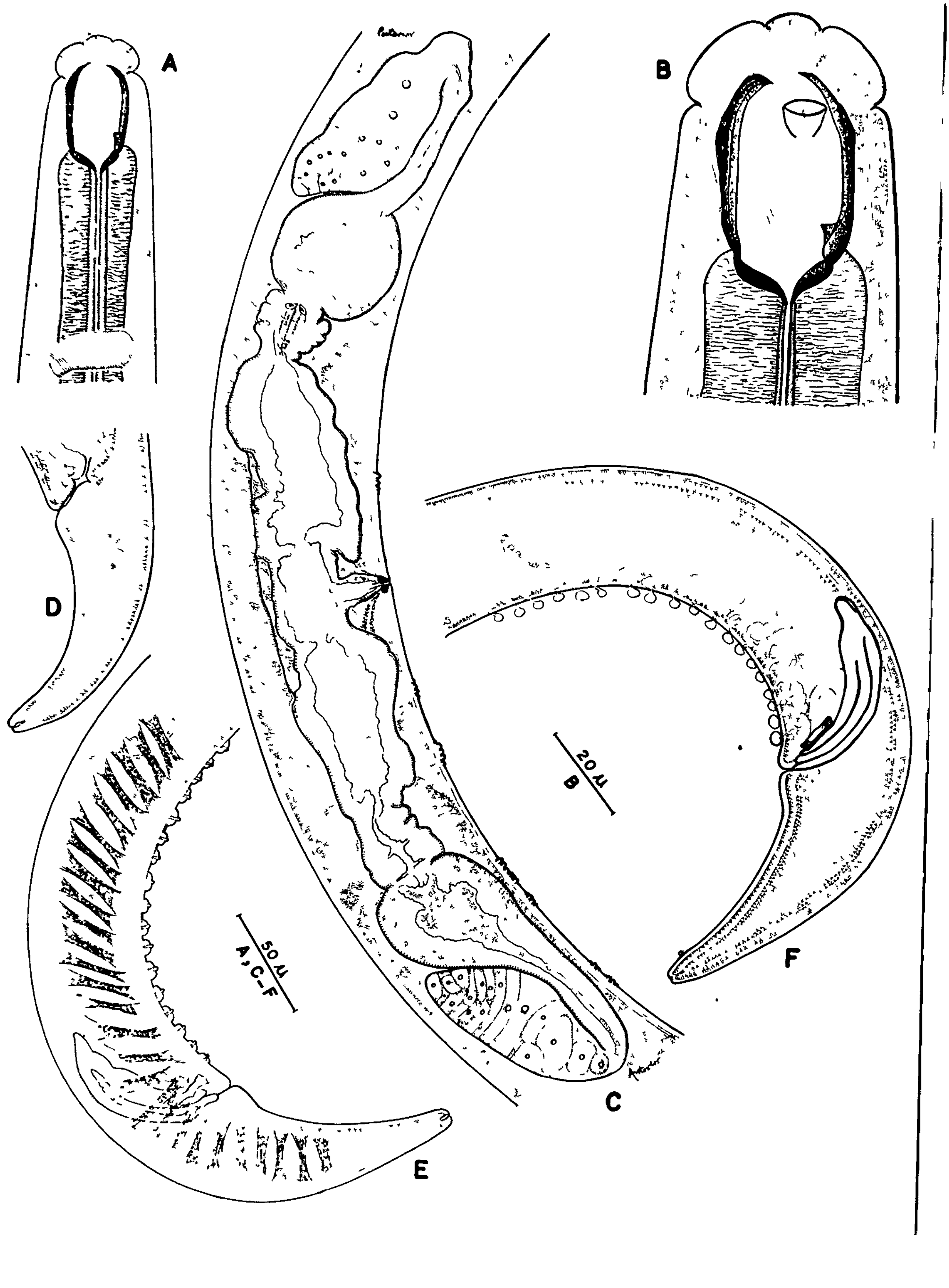
A. Head end of female.

B. Head end of female (magnified).

C. Female gonads.

D. Female tail.

E & F. Male tails.


A
B
C
D
E
F
50 μ
A, C–F
20 μ
B